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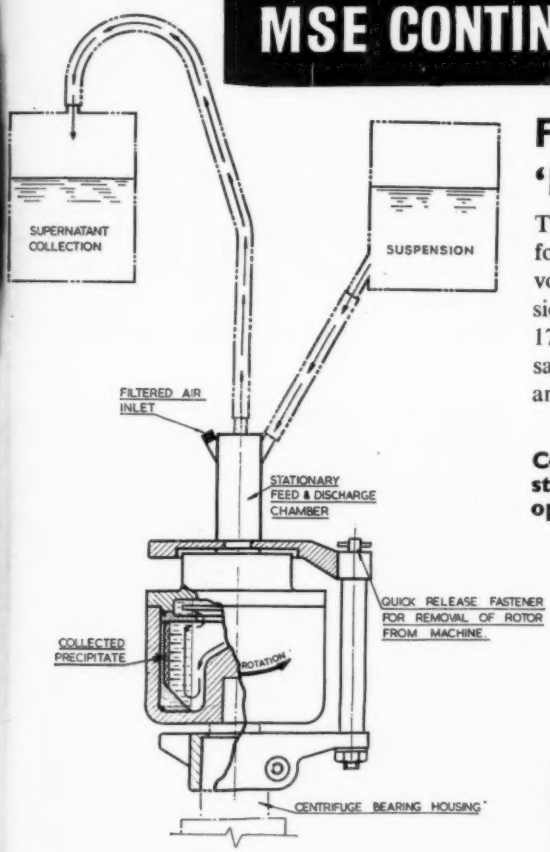

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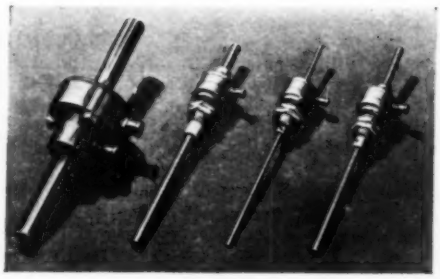

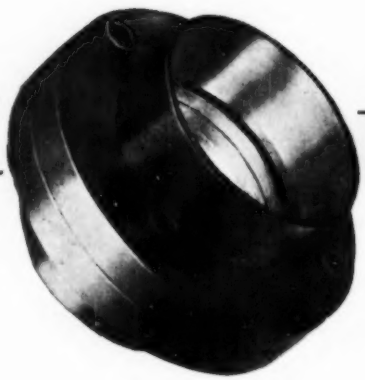

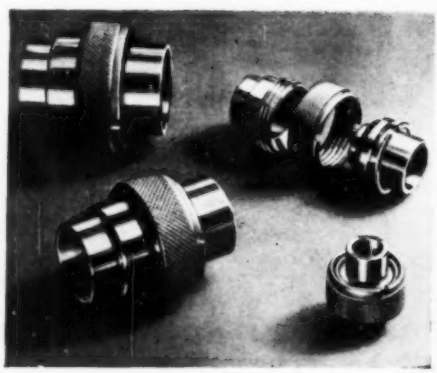

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THE GREY SEAL AND BRITISH FISHERIES

THE grey seal (*Halychoerus grypus*) appears to have increased considerably in numbers on the coasts of Great Britain during the past forty years. Except from one place, however, there are no comparative figures to show how great the increase may be, or even whether the apparent increase is real. The exception is the Farne Islands where, although the colony of grey seals had been exploited commercially on a small scale for many years during the past century, the population was estimated to number 600–800 in 1928. The National Trust came into possession of the Islands in 1925, and since then the seals have been completely protected. Counts by members of the Natural History Society of Northumberland, Durham and Newcastle upon Tyne have shown that the seal population had increased to 3,000 in 1957, and that it is now about 3,500. It is unfortunate that we have no similar comparative counts of the population in any of the other colonies of grey seals on the coasts of Britain.

For long the grey seal was believed to be a rare British animal, largely because of the vernacular name of *Phoca vitulina*, the common seal. It is difficult for people who are not familiar with the differences between the two native species to identify the animals in the water, for little except part of the head is generally visible. Consequently it has long been customary to assume that any seal seen by chance is a common seal, an assumption that is now known to be unwarranted, for on many parts of the coast the common seal is uncommon, and the grey seal is the species usually seen. It was probably largely this misapprehension that led to the passing of the unnecessary grey seals Protection Act in 1914, a private member's Bill that was slipped through Parliament late at night by a bare quorum at the instigation of a person whose interest in seals seems to have been confined to slaughtering them. This Act, and the second Act of 1932 which protects the grey seal in its breeding season during September 1–December 31, have until recently not been taken very seriously, even by Government departments.

Since 1945 the British seals have attracted the attention of a number of zoologists, who have published numerous papers on their anatomy, physiology, ethology, and general natural history. As a result of these researches, it has become plain that the grey seal is a much commoner animal than was formerly believed; but it is impossible owing to the lack of exact observations in the past to know whether this is due to an increase in the number of seals or in the number of zoologists interested in them. It is equally difficult to form an objective judgment about the complaints of the Scottish salmon netters, who capture salmon in inshore waters and estuaries, that the numbers of grey seal have increased inordinately. Past records show that salmon netters have always complained of the depredations of seals, and have used various methods to kill them or drive them away, sometimes with conspicuous success.

There is no doubt that seals do inflict considerable damage on salmon nets, and that they destroy or maul some of the salmon captured in them. It is not surprising, therefore, that the net proprietors feel aggrieved that a large population of grey seals, which is known to have increased four- or five-fold in the past thirty years, should enjoy complete protection on the Farne Islands, especially since a number of seals tagged on the Islands have been entangled and drowned in their nets. The netters wish the seal population of the Islands to be drastically reduced, but they are opposed on humanitarian grounds by many people whose material interests are not involved; unfortunately, strong emotions have been aroused on both sides. An attempt at culling some of the young pups in 1959 was unsuccessful for various reasons, and, moreover, it is not certain that control of numbers by killing unweaned pups is the best method. So far as our present knowledge goes, more than 50 per cent of the pups die from natural causes before they reach the age of one year; it therefore seems superfluous to kill pups when so many of them will be dead within twelve months even if no action is taken. Information is not yet available to show whether the killing of adult seals on their breeding grounds is an effective method of control. The breeding colonies are comparatively few, and the concentration of adults on them is high; the breeding grounds therefore appear to be the places where a large reduction of numbers could be attained easily and quickly. But isolated attempts at reducing the seal population by slaughtering some of the animals at one or two colonies do not seem likely to have any permanent effect of significance.

It is by no means certain that all the damage complained of is inflicted by seals from the Farne Islands; nothing is known about the movements of the seals from the much larger colony in Orkney which may be contributing to the damage. It seems improbable, too, that all the seals from these colonies are regularly preying on salmon and damaging the nets. The seal populations are known to total many thousands, yet the seals seen at the fishing stations are counted in dozens or less; if all the population were preying on salmon, the netters' latest returns would be expected to be the worst ever made instead of being among the best. There is some evidence that the damage is inflicted by a minority of the population, and that damage stops when this minority

is removed; but what part of the population is responsible for the damage has not yet been ascertained. There is also evidence that there is some segregation of the population into sex- and age-groups, but much more information is required on this point. The recovery of seals marked as pups has proved that some of them at least travel very long distances in the first few months of their lives, for example from the Farne Islands to Norway, Faroe, and the coasts of Germany, Holland, and Belgium. The movements of older animals have yet to be traced; regular tagging has been carried on for less than ten years, and it is probable that the methods used at first were not efficient, so that the seals lost their tags after a comparatively short time.

It is thus evident that no satisfactory policy about grey seals in relation to fisheries can be settled until the requisite knowledge about their natural history has been obtained. It is for this reason that the Nature Conservancy is at present sponsoring a three-year programme of research on the grey seal, financed partly by the Development Commissioners.

In a recent paper* which should form a useful background to this investigation, Dr. B. B. Rae has attempted to gather together all that has been written about the grey and common seals in relation to fisheries since the passing of the Grey Seal Protection Act in 1914. Unfortunately, Dr. Rae mixes the vague statements of untrained observers with the relatively few proved facts, and tends to reach conclusions some of which start from false premises; he sometimes appears to abandon objectivity by straining to build up a case against the grey seal with statements that are not adequately supported by evidence. There is a *prima facie* case against the grey seal, but the solution of the problems it presents can only be found by patient research and the laying aside of all emotion and bias on both sides. The work is in hand, and if faithfully and diligently prosecuted, there is no doubt that the desired result will be attained.

* Department of Agriculture and Fisheries for Scotland. Marine Research 1960, No. 2 : Seals and Scottish Fisheries. By Dr. Bennet B. Rae. Pp. 39 + 9 plates. (Edinburgh and London : H.M. Stationery Office, 1960.) 15*s.* net.

MIRŒSTROL: AN ŒSTROGEN FROM THE PLANT *PUERARIA MIRIFICA*

By Dr. JAMES C. CAIN
National Research Development Corporation, London, W.1

IN 1936, Dr. S. J. Folley, working at the National Institute for Research in Dairying at Shinfield, in England, found that the injection of œstrone or œstradiol benzoate into lactating cows caused prolonged increases in both the fat and the non-fatty solids content of the milk[1]. This 'enrichment effect', as it was then called, was later confirmed and further investigated by Folley and his colleagues[2].

During the early spring of 1948, Dr. H. W. Bennetts, of Perth, Western Australia, discussed with Drs. Bartlett and Folley his findings that reproductive disorders in sheep were due to the ingestion of œstrogenic compounds apparently present in subterranean clover, which at that time was the principal diet of sheep in Western Australia. In view of this finding and the work reported above by Folley and his colleagues, it was decided to initiate work at the National Institute for Research in Dairying on œstrogens in pasture herbage. Dr. Bennetts kindly provided helpful information on the techniques which he had found useful, and advice and help was also sought and obtained from Sir Charles Dodds and his colleagues at the Courtauld Institute of Biochemistry, Middlesex Hospital, London, where also at that time D. H. Curnow, a research worker from Western Australia, was studying herbage œstrogens.

In May 1948 œstrogenic activity was demonstrated in the pasture herbage from a field adjoining the National Institute for Research in Dairying by Bartlett and his colleagues[3]. This finding posed a host of questions of practical significance for the solution of which it was clear that the resources available at that time at the Institute and the Courtauld Institute needed to be strengthened on the chemical side. Accordingly, in 1949 Dr. G. S. Pope joined the staff at Shinfield for work on œstrogens in pasture plants; the progress of this work has already been reported[4].

In the early stages of the work, when attempts were being made to isolate the œstrogens of red clover (aerial portions of the plant), attention was directed to the chemically new and highly potent œstrogen isolated in 1940 by Schoeller, Dohrn and Hohlweg[5] from the tuberous roots of a leguminous plant in Thailand, investigated from a chemical point of view by Butenandt[6] (1940). It was evident that this plant source was at least a hundred times as rich in œstrogenic activity as red clover and it became of considerable interest for two reasons. The first was that since both it and red clover are of the family Leguminosae, it seemed likely that the slight activity of red clover was due to a low content of the same new œstrogen as found in the plant in Thailand, and, therefore, that study of the latter might greatly help the work with red clover. (In the event this forecast proved to be wrong, as the activity of red clover was found to be due to the very slightly potent *iso*flavonoid œstrogens.) The second reason was a natural interest in the new, highly potent œstrogen for its intrinsic value.

At this stage, Mr. D. C. Rivett-Carnac, of the British Embassy, Bangkok, with whom the workers at Shinfield were in touch, directed attention to certain relevant information in some of the Thai scientific journals.

Kerr[7] in 1932 was the first to direct public attention to the fact that the tuberous roots of the Thai plant concerned, a woody climber found in the forests of northern Thailand and known locally as *kwao keur*, were considered to be of value as the active constituent of a rejuvenating drug. The information came to him privately from Mr. H. B. Garrett and Dr. E. C. Cort, and the conclusion reached was that the plant was *Butea superba*. Following Kerr's paper, various workers began to collect the roots, and in 1939 Vatna[8] showed the presence of œstrogen in *kwao keur*, this being confirmed by Schoeller *et al.*[5]. It became clear, however, after detailed botanical investigation in Thailand, that the name *kwao keur* was, in fact, applied to several species of plant having tuberous roots, and that those yielding the new œstrogen belonged to an unnamed species of *Pueraria*, superficially very similar to *Butea superba*. The name *Pueraria mirifica* was given to it by Lakshnakara Kashemsanta, Kasin Suvatabandhu and Airy Shaw[9].

In 1952 a gift of 6·1 kgm. of dried *Pueraria mirifica* root was received at Shinfield from Mr. Kasin Suvatabandhu, and in 1953 and 1954 batches of 9 kgm. and 4 kgm. were again obtained through the generosity of Mr. Kasin Suvatabandhu and with the assistance of British Council staff in London and Bangkok. Bioassay, using the mouse uterine growth test, of a crude methanol extract of the powdered root confirmed the high œstrogenic activity of the material. The crude methanol extract (6 per cent by weight of dried root) was then submitted to conventional solvent partition procedures giving a product (0·6 per cent by weight of dried root) which contained more than 50 per cent of the œstrogen. Further purification was effected by partition chromatography on kieselguhr columns, and certain fractions from these crystallized in part and yielded a crystalline product (58 mgm. from 6·1 kgm. dried root) when washed with ethyl acetate. Recrystallization from methanol yielded as thin rectangular plates a colourless crystalline product, melting with decomposition at 268° C. (Kofler apparatus). This product appeared to be homogeneous when chromatographed on paper in three different solvent mixtures, in each case showing as a pink spot on reacting with 5 per cent aqueous potassium carbonate and diazotized *p*-aminophenyl 2-diethylaminoethyl sulphone. It appeared, therefore, that the product, of melting point 268° C., was a pure compound, and on testing for œstrogenic activity it was found to be equal to œstradiol-17β in potency in the mouse uterine growth test, and to have one-quarter of the potency of œstradiol-17β in the rat vaginal cornification test, in each case œstrogens being administered by subcutaneous injection. The name 'mirœstrol' was given to the œstrogen; it is doubtless identical to the compound isolated by Schoeller *et al.*[5].

For further biological and chemical work, and especially for an attack on the structure of mirœstrol, much larger quantities of the tuberous roots were required. Dr. S. Bartlett was responsible for the arrangements eventually made to collect additional supplies of the root, and he personally supervised the collections on site. The only place where the plant was known to grow was in the forest near Chiengmai in northern Thailand, and it was clear that supplies could only be obtained by means of a collaborative effort with the appropriate local authorities. Those who gave generous help and advice included Prince Lakshnakara Kashemsanta, Mr. Kasin Suvatabandhu, the director and staff of the Maejo Agricultural Experimental Station at Chiengmai, and Mr. R. J. Hilton, head of the British Council Department in Bangkok.

At this time the interest of the National Research Development Corporation was sought and obtained in this work. The chemical novelty was certain at this stage; the point was whether the structure, when known, might be readily accessible by synthesis from known and abundant substances. The Corporation accordingly undertook to obtain whatever patent protection was possible in the light of prior knowledge and publication and agreed to finance an additional chemist, Dr. D. G. Bounds, at Shinfield, and certain other costs likely to be incurred in the collection of the root, the extraction of mirœstrol and the determination of its structure.

Two plant-collecting expeditions to Thailand were then undertaken by Dr. Bartlett. The first in 1954, yielding 120 kgm. of dried root, was financed mainly by a grant from Quaker Oats, Ltd., but in part by the National Research Development Corporation, and the second in 1957, which was wholly financed by the latter, yielded 200 kgm.

Mr. Suvatabandhu, a well-informed Thai botanist, knows of only two places in Thailand where quantities of the plant *Pueraria mirifica* grow; one place is at the foot of the mountain Doi Suthep near Chiengmai, and the other is nearly 100 miles farther north at Chieng Dao.

The plant clearly has a local reputation as a rejuvenator. At Chieng Dao, Dr. Bartlett and his Thai colleagues were travelling by car in search of the plant and asked one of the men who were repairing the road if he knew the plant, and he replied, "Yes, we eat it!" The tubers of the plant are almost flavourless and somewhat turnip-like in consistency, and as the Thais are not short of food it may be assumed that *Pueraria mirifica* is eaten for some purpose other than as ordinary food. Further evidence of local interest in the plant may be gleaned from the fact that Mr. Puk Pakkasem, a member of the office staff at the British Consulate at Chiengmai, was able, when requested, to obtain in a few hours thirty local inhabitants who were able to locate the plant in the forest and dig it.

An interesting episode occurred in November 1954, when Dr. Bartlett visited the Siam City Bank in Chiengmai accompanied by Mr. Suvatabandhu. During casual conversation the bank manager, Mr. Kraisri Nimmanahaeminoa, showed great interest in the fact that they were collecting *kwao* and said his grandfather used to make medicine from the plant and had written a pamphlet about it. Mr. Nimmanahaeminoa provided a copy of the pamphlet and a pot of 'medicine', which appeared to be a 50 : 50 mixture of dried kwao and honey; it was made in 1953. The pamphlet, in the Thai language, was kindly translated by Mr. Stuart Simmonds, of the School of Oriental and African Studies, University of London, and gave the following information: On the cover was a diagrammatic but accurate sketch of the plant and the description: "Treatise on the Drug made from the Tubers of the Kwao Vine by Luang Anusar Sunthon, Special Commissioner, Chiengmai. Printed at the Upati Pongs Printing House, 3000 copies, May 1931". The main source of information for the pamphlet was a treatise written on palm leaves by 'ancients' and stored in a temple at Pagan, the old capital of Burma. The temple was wrecked by lightning, and the treatise then came to light.

The drug is said to be well known in Burma, where it is called 'paukse', and is stated to rejuvenate old men and women, but should not be taken by young people. One man who took the drug was reputed to have lived to 280 years of age. This local folklore, which appears to ascribe remarkable properties to the *kwao* (or *Pueraria mirifica*) in Burma and Thailand, may well be responsible for the comparative scarcity of the plant. It is not known whether it grows in Burma, but the area of Pagan mentioned in the pamphlet is now said to be an arid desert due to the forest having been cut down in order to build temples.

The pharmaceutical properties of *Pueraria* are considered, in Thailand, to include toxicity, and a careful study of the constituents of the plant has been made in the Chemistry Department of the University of Bangkok. At the Ninth Pacific Science Congress at Bangkok in November 1957, an interesting paper was presented on the "Constituents of the Tuberous Roots of *Pueraria mirifica*" by the Thai workers, T. Nilanidhi, B. Kamthong, K. Isarasona and D. Shiengthong (unpublished work), in addition to a joint one by the Thai and United Kingdom workers, Lakshnakara Kashemsanta, Kasin Suvatabandhu, Bartlett and Pope, on "The Œstrogenic Substance (Mircestrol) from the Tuberous Roots of *Pueraria mirifica*"[10].

The collaboration of the Director of the Royal Botanic Gardens at Kew was sought in an attempt to grow plants of *Pueraria mirifica* there. The first two attempts were unsuccessful, but the third plant, kindly sent from Thailand by Col. E. H. Jacobs-Larkcom, grew and is still growing vigorously. In December 1958 Miss Joy Jacobs-Larkcom collected a number of additional plants in Chiengmai, and these are now also planted in Kew Gardens.

The roots obtained by the expeditions to Thailand were utilized for the following purposes in the studies on mircestrol.

(*a*) *Improvement of the method of isolation.* The method of isolation has been simplified, and recovery of around 15 mgm. mircestrol per kgm. dried root is now a routine procedure. Paper chromatography, using periodate as reagent, which provides a very sensitive and almost specific colour test for mircestrol, gives efficient analytical control.

(*b*) *Determination of physical properties.* Mircestrol has been found to crystallize in two forms, a stable hydrated form (stout needles), which after desiccation quickly regains its water of crystallization when exposed to moist air, and a non-hygroscopic, anhydrous form (thin rectangular plates). The latter form has a sharp melting point of 268° C., with some decomposition on melting (Kofler apparatus, rheostat setting 350° C.). Like many steroid hormones, mircestrol has a high dextrorotatory power, $[\alpha]_D^{17}$ + 301° (1·08 gm./100 ml. in ethanol). Its ultra-violet and infra-red absorption curves have also been useful criteria of the purity of the various specimens isolated.

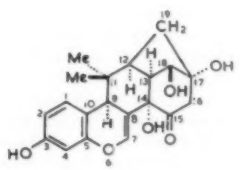
(*c*) *Determination of œstrogenic potency.* In addition to the properties already noted, mircestrol has been found to have high œstrogenic potency when given orally: approximately three times that of stilbœstrol in the immature mouse uterine growth test[11] and two-thirds that of stilbœstrol in the rat vaginal cornification test. It has also 70 per cent of the activity of œstradiol-17β when administered by subcutaneous injection, in promoting mammary duct growth in the rat, and is 2·2 times as active as œstrone by a similar test in the mouse[12].

(*d*) *Preliminary chemical studies.* Elementary analysis and molecular weight determination in Dr. Dorothy Hodgkin's laboratory, University of Oxford, using the X-ray method, gave $C_{20}H_{22}O_6$ as the molecular formula for mircestrol, or less probably $C_{20}H_{24}O_6$. Analysis of the monomethyl ether and monoacetate, in each case the phenolic hydroxyl (see below) having reacted, supported this finding. Other derivatives of mircestrol were then prepared, details of which have been reported elsewhere[13], and from the ultra-violet and infra-red absorption curves of these and their chemical properties it was concluded that mircestrol is a monohydric phenol possessing one carbonyl and at least two alcoholic hydroxyl groups.

(*e*) *Preparation of a derivative of mircestrol for X-ray analysis.* The complete elucidation of the structure of mircestrol solely by chemical methods appeared likely to be very difficult with the small amount of material available. It was therefore decided to employ X-ray crystallographic analysis to solve the problem, using three-dimensional methods on a heavy-atom derivative. This work was carried out by Dr. Dorothy Hodgkin and her colleagues at Oxford.

Dr. D. G. Bounds succeeded in making a monobromo-substitution product of mircestrol. At first, bromination of mircestrol with one molecular proportion of bromine gave complex mixtures, but reaction conditions were eventually found which gave a mixture containing only two main products. These were isolated by partition chromatography, and from the elementary analysis and ultra-violet and infra-red absorption curves of one of these compounds, it was concluded that in this compound a single bromine atom had entered the mircestrol molecule replacing a hydrogen atom and that no other chemical changes had taken place. The fact that the monobromo-mircestrol isolated coupled much less readily than did mircestrol with diazotized *p*-aminophenyl 2-diethylaminoethyl sulphone was taken as good evidence that the bromine atom was present as a substituent in the benzene ring of mircestrol.

(*f*) *X-ray studies.* X-ray crystallographic measurements on monobromomircestrol were made by Dr. Noel E. Taylor, and the crystal structure was solved in collaboration with Dr. Hodgkin and Dr. J. S. Rollett through a series of three-dimensional electron density calculations carried out on *Deuce* at the National Physical Laboratory. The positions of the atoms found by these calculations are illustrated in Figs. 1 (*a*) and (*b*). They lead to the structural formula I, for mircestrol itself:



(I)

Full details of this work have been reported elsewhere[14].

Biogenetically, it seems possible to dissect the nucleus into an isoprene unit and a partly reduced *iso*flavene nucleus. This dissection relates it, on one hand, to the many plant products in which isoprene units are found linked to condensed ring systems (cf.

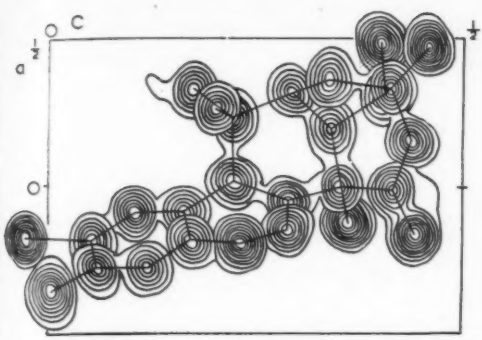


Fig. 1 (*a*). Electron density-levels over the peaks in $\rho 3$ in bromomircestrol. The structure is seen projected along [010]. Contours at intervals of approximately 1 el./A.^{3} except over the bromine atom, where the intervals are 4 el./A.^{3}

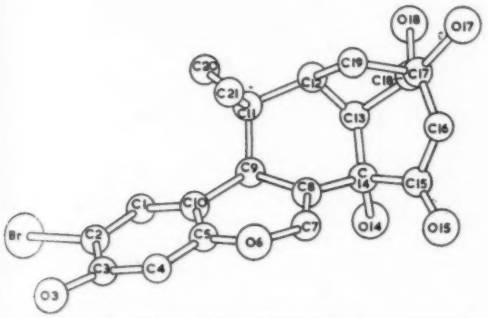


Fig. 1 (*b*). A view of the molecule of bromomircestrol, drawn from the atomic positions in $\rho 3$

Robinson[15]), and, on the other, to those *iso*flavones and *iso*flavenes which have been shown to have œstrogenic properties. Mircestrol is not a steroid, and the biological activity is probably a consequence of accidental features of molecular geometry. The actual distance from the 3-OH in mircestrol to the 18-OH is 10·3 Å., which is very near the distance to be expected from models of the 3-OH to the 17-OH of œstradiol. When, however, one compares the disposition of the 17-OH of mircestrol and the 16-OH of œstriol relative in each case to the 3-OH, the similarity is not so close; but perhaps it is worth noticing in this connexion that mircestrol is the more potent œstrogen.

(*g*) *Limited clinical trial.* The trial was carried out by Dr. P. M. F. Bishop and his colleagues at the Chelsea Hospital for Women, London.

Mircestrol has been administered to ten women suffering from amenorrhœa (primary, two cases; secondary, seven cases) or artificial menopause (one case). 5 mgm. daily was given on six occasions and 1 mgm. daily on another six occasions. Marked œstrogen response was noted with both these doses on the vaginal smear, the maximum rise in the cornification index usually occurring during the second or third week after treatment commenced. This peak usually occurred, therefore, after the treatment had been discontinued. Œstrogen withdrawal bleeding failed to take place on six occasions (three with doses of 1 mgm. daily from 5 to 10 days; three with doses of 5 mgm. daily from 2 to 14 days), though withdrawal bleedings had usually occurred in these patients when they had been previously treated with œstrogens. Withdrawal bleeding did take place on five occasions, however, 7–18 days after the cessation of treatment. The withdrawal interval is much longer, therefore, than with most other oral œstrogens. No toxic effects were complained of on three occasions, the doses being 1 mgm. daily for 7 days, 5 mgm. daily for 8 days and 5 mgm. daily for 14 days, respectively. Toxic effects were rather marked on the remaining nine occasions and consisted of malaise, headache, nausea and in some instances vomiting. They did not seem to be appreciably less severe on the 1-mgm. doses than on the 5-mgm. doses. Work with 0·1-mgm. doses is being undertaken. On four occasions there was enlargement and tenderness of the breasts. These changes were more severe and more frequent on the 5-mgm. doses. On two occasions they were accompanied by marked pigmentation of the nipples, which persisted for some time. In the patient who had received an artificial menopause the hot flushes diminished in frequency and severity for the first week of the 14-day course, but began to return by the fifth day after treatment had been discontinued.

In the light of the limited experience described, it would seem that mircestrol produced marked œstrogenic response in the vaginal smear; is rather slow to act and its effect takes some time to wear off. It does not always induce a withdrawal bleeding, and in the doses so far employed is apt to give rise to rather disagreeable toxic effects.

In view of the undesirable side-effects of mircestrol, it appears unlikely that this substance itself will be suitable for use in medicine in spite of its high level of œstrogenic activity by the oral route. It is possible that modifications of its structure might lead to useful œstrogens, but it is evident that a total synthesis of the whole molecule would be difficult, and not likely to be commercially feasible; also although the mircestrol structure is new, it is, as noted above, related in part to already known œstrogens, and therefore does not display as great a novelty in regard to its structure/action relationship as was at first thought possible; nevertheless, mircestrol presents some features of interest, and further investigations of its biological properties are proceeding.

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HIGH-ENERGY PHYSICS

TENTH ROCHESTER CONFERENCE

THE annual international conference on high-energy physics, known more commonly as the 'Rochester Conference', has, over the past decade, produced a sequence of elaborate progress reports on the status of current experimental and theoretical research in one of the most rapidly growing fields of physics. Under the leadership of Prof. Robert E. Marshak, it began in 1950 as an informal seminar at which a handful of specialists considered the implications of the newly discovered π-mesons. When even newer classes of particles were observed in cosmic radiation, and when the great accelerators began to operate, the scope of the conference naturally widened, so as gradually to encompass all the problems that make up the modern science of particle physics. The size of the delegation increased as well, reflecting the growth in the number of physicists engaged in these problems. At the tenth Conference, which was recently held in Rochester, 350 delegates from more than twenty nations gathered in order to assess the results of their most recent research, and to plan the work that lies ahead. The meeting lasted from August 25 until September 1. During the first two days, detailed reports were presented in four simultaneous sessions. These were followed by four plenary sessions during which the earlier discussions were summarized by *rapporteurs*, and three sessions of invited papers on topics of general interest. It is impossible to give a useful account of all these proceedings in abbreviated form, particularly when it is addressed to an audience of non-specialists. I have therefore chosen to review the set of fundamental principles toward the study of which the work at high energies is being directed. I shall then describe some of the more prominent features of the tenth Conference, emphasizing those reports that appear to provide new links in the chain of argument.

Outside gravitation, which seems to play no significant part in nuclear physics, there are three kinds of forces in Nature. The most familiar of them is the electromagnetic interaction, for which the classical theory was developed by Maxwell and Lorentz. Its extension to microscopic phenomena has been achieved in a quantum theory of electrodynamics. The theory describes the interaction in terms of the typical virtual process $e \rightarrow e + \gamma$, where e is any charged particle and γ is a photon. The symbol e also represents the unit of charge, of which all natural charges appear to be exact multiples. The strength of the interaction is measured by the dimensionless universal constant $e^2/\hbar c = 1/137$, $\hbar$ being Planck's constant and c the speed of light in vacuum. The theory has scored many successes, and its essential validity, except possibly at very high energies, is not questioned.

The second kind of force encompasses the 'strong' interactions between particles of certain classes. A quantum field theory of the strong interactions has developed from the original work of Yukawa, and is typified by the virtual process $p \rightarrow n + \pi^+$, where p is a proton, n a neutron, and π^+ a positively charged pion. The dimensionless coupling constant for the pion-nucleon interaction is $g^2/4\pi\hbar c \simeq 14$, where g has the physical dimension of charge. The fundamental significance of the charge g is no more clearly understood than that of the electric charge e. Furthermore, the coupling constants associated with other strong interactions are presumably different, but all are believed to be of the same order of magnitude. Because of several technical difficulties the theory of strong interactions has proceeded cautiously, guided closely by new experimental discoveries. But certain simplified forms of the theory, developed principally by Chew and his collaborators, have provided semi-quantitative descriptions of many phenomena.

We encounter finally the 'weak' interactions, which are the most mysterious of all the forces. They are typified by the β-decay of a nucleon; for example, $n \rightarrow p + e^- + \bar{\nu}$, where $\bar{\nu}$ is an antineutrino. Weak interactions couple other classes of particles as well. There is no experimentally identified field quantum, analogous to the photon and the pion, associated with the weak interactions. The present description of the phenomena is a development of the original work of Fermi. In his theory, the coupling constant characteristic of a weak interaction is not immediately dimensionless, but it is conventionally written in units that involve the Compton wave-length of the charged pion. Weak couplings so defined have strengths of the order of 10^{-14}, a number to be contrasted with 10^{-2} for the electromagnetic coupling, and with 10 for strong coupling. It appears that weak interactions have at least roughly the same strengths in all their manifestations. This observation has led to the hypothesis of the universality of weak interactions, but a precise formulation of the principle has not yet been made, nor has it been applied quantitatively to experimental data in an unambiguous way. A great advance in our knowledge of weak forces was recently initiated by Lee and Yang. Their suggestion that the interactions need not be invariant to spatial reflexion has been experimentally verified in many different ways, and has led to important clarifications of symmetry principles underlying all physics.

The particles of physics, among which the three types of forces are supposed to act, are separated first into two general groups: the bosons and the fermions. By definition, bosons have spins (intrinsic angular momenta) that are integral multiples of $\hbar$. Fermions have half-integral spins. Bosons are regarded as the quanta of the several kinds of field. Thus photons, with spin unity, are quanta of the electromagnetic field; pions, with zero spin, are quanta of the strong nuclear field. If quanta of the weak field exist, they are also presumably bosons. There is no conservation principle governing the number of bosons that may be created or destroyed in a collision. It is only necessary that energy, momentum, angular momentum, and charge be conserved. The number of fermions, on the other hand, is believed to be subject to strict conservation laws which I shall discuss shortly.

The bosons specifically associated with strong interactions are called 'mesons', and two classes of these particles have so far been observed. In addition to the pions (π) with masses near 0·14 BeV., there are the heavier 'kaons' (K) with masses near 0·50 BeV. (By the 'mass' of a particle I mean, of course, its rest mass. It is most convenient to write rest masses as rest energies in units of MeV. (10^6 electron-volts) or BeV. (10^9 electron-volts).)

There are two sets of fermions. One consists of particles lighter than the mesons, and are called 'leptons'. It includes the neutrino (ν), the electron (e^-), and the muon (μ^-). (Although once called the 'μ-meson' because of its intermediate mass, the muon does not conform to the modern definition of a meson.) The neutrino has zero mass, the electron mass is about 0·5 MeV., and the muon mass is about 106 MeV. The other set of fermions consists of particles heavier than mesons, and is called the set of 'baryons'. It includes the nucleons (N) with masses of about 0·94 BeV.; the Λ-hyperon, with mass 1·12 BeV.; the Σ-hyperons, with masses near 1·19 BeV.; and the Ξ-hyperons, with masses of about 1·31 BeV. The spins of all fermions are almost certainly 1/2. The baryons interact strongly with each other and with the mesons, and weakly with the leptons.

One may well wonder about the meaning of the term 'elementary particles'. The early periods of modern physics were characterized by searches for ultimate constituents of matter, and there were times when it appeared that the search had ended. The current point of view on this matter is somewhat different. The concept of an elementary particle is now thought to be useful only within a specific context of the contemporary experimental and theoretical situation, taking into account the types of interaction that one is investigating, and the particle properties that one regards as fundamental. In this sense the present list of elementary particles need not be final, even if no new species are discovered.

So far I have mentioned ten classes of particles (γ, ν, e^-, μ^-, π, K, N, Λ, Σ, Ξ). A further subdivision occurs when we take account of the different states of electric charge which most of the mesons and baryons can assume. Thus the π has three charge states (π^+, π^0, π^-); the K has two (K^+, K^0); the N has two (p, n); the Σ has three (Σ^+, Σ^0, Σ^-); and the Ξ has two (Ξ^-, Ξ^0). We then have a total of 17 particles. Furthermore, there is believed to be an antiparticle associated with each particle, having properties that are very simply related to those of the particle. This would give a total of 34. However, four of the antiparticles ($\bar{\gamma}$, $\bar{\pi}^+$, $\bar{\pi}^0$, $\bar{\pi}^-$) are experimentally indistinguishable from four of the particles. In this way, we arrive at the 30 unique objects which are under study in high-energy physics.

The multiplicity of charge states bears much formal resemblance to the multiplicity associated with ordinary spin. This observation has led to the idea of an 'isotopic spin vector', I, connected with a given particle or system of particles, and an isotopic spin space in which the vector resides. The z-component of isotopic spin, I_z, selects one of the possible multiplets of the system. For example, the vector I has magnitude unity for the π, with three possible projections on the z-axis representing a triplet (π^+, π^0, π^-). The importance of isotopic spin to the subject rests in the observation that I appears to be strictly conserved in strong interactions. The idea has not yet been given significance in the description of leptons.

The mathematical transformation of a particle into its antiparticle is called 'charge conjugation', and is denoted by the operator C. It is equivalent to a reflexion in isotopic spin space. Under the assumption that particle physics conforms to the principles of special relativity, it has been shown that perfect symmetry exists between a particle and its antiparticle. The two have the same mass, spin, lifetime, and modes of decay; they have opposite charge and magnetic moment. This symmetry is beautifully apparent in the electron-positron pair, on which precise experiments have been done. One believes not only that each of the other antiparticles exists (some of the antihyperons have yet to be discovered) but also that it must exhibit the same symmetry. Another powerful theorem based on relativity has been proved by Pauli and Lüders. It asserts that all interactions are invariant under the combined operation CPT, where C is charge conjugation, P is spatial reflexion (the parity operation), and T is time inversion.

All the conservation and invariance principles that are currently accepted in particle physics can now be stated in summary form. Some are taken over from classical physics, but most have only recently come to light as generalizations from new experiments. The list is as follows:

(A) Principles valid in all interactions:
1. Conservation of energy and momentum.
2. Conservation of angular momentum.
3. Conservation of charge.
4. Conservation of baryons (number of baryons minus number of antibaryons).
5. Conservation of leptons (number of leptons minus number of antileptons).
6. Lorentz invariance (CPT theorem; symmetry of particle and antiparticle).
7. Invariance under T (time inversion).

(B) Principles valid in strong and electromagnetic interactions, and violated in weak interactions:
8. Invariance under charge conjugation.
9. Invariance under spatial reflexion.
10. Conservation of I_z.

(C) Principle valid in strong interactions, and violated in electromagnetic and weak interactions:
11. Conservation of I.

In addition to these strict principles, there are several recently formulated selection rules for which much evidence has accumulated. The most completely confirmed of them states that, when mesons or baryons decay into one another, the magnitude of I for the system changes by $\frac{1}{2}$. This rule and some of the conservation principles can be illustrated by considering the modes of decay of the Λ-hyperon. The particle is electrically neutral, has half-integral spin, and has zero isotopic spin. There are several decay modes which are consistent with principles 1–5. Those that involve no more than three decay particles are:

$$\Lambda \to n + \pi^0 \quad (1) \qquad \Lambda \to p + \mu^- + \bar{\nu} \quad (5)$$
$$p + \pi^- \quad (2) \qquad n + \nu + \bar{\nu} \quad (6)$$
$$n + \gamma \quad (3) \qquad n + e^+ + e^- \quad (7)$$
$$p + e^- + \bar{\nu} \quad (4)$$

Since the first two modes involve only baryons and mesons, which are strongly coupled to each other, we might expect that the decay would proceed very

rapidly through these channels. But notice that the isotopic spin of the system $N + \pi$ must be a combination of two vectors the magnitudes of which are $\frac{1}{2}$ and 1 respectively. The only isotopic spin states allowed for this system are $I = 1/2$ and $3/2$. Therefore neither I nor I_z can be conserved, and a decay through strong interactions is impossible. The non-conservation of I_z also inhibits the radiative decay (3). We see in addition that, although decay modes of the type $\Lambda \rightarrow N + \overline{K}$ would satisfy conservation of isotopic spin, the mass of the final state exceeds that of the Λ and the mode is impossible if energy is to be conserved. We have thus shown that the particle cannot decay through strong interactions. Furthermore, since the decay does in fact proceed slowly through channels (1) and (2), we know that a weak interaction couples the particles, and we can use the decay rate to obtain an estimate of its strength. (If the Λ could decay through a strong interaction, its life-time would be of the order of 10^{-23} sec. The observed life-time is about 10^{-10} sec.)

Of the remaining modes of decay, (4) and (5) are not forbidden by any known rules, and can be expected to occur as poor competitors of (1) and (2). The remaining modes are forbidden by selection rules that have not been mentioned. Finally, it is to be noted that the $\Delta I = \frac{1}{2}$ rule requires the $N + \pi$ system in the Λ decay to occur only in the $I = \frac{1}{2}$ state. One can deduce from this that the mode $p + \pi^-$ should occur twice as frequently as $n + \pi^0$, a prediction that is well confirmed by experiment.

The fact that Λ cannot decay promptly permits us to regard it as an elementary particle, even though its life-time is short by ordinary standards. The situation is similar for all the unstable elementary particles, which constitute a majority of the list already given. Outside the stable particles (γ, ν, e^-, p), the longest lived is the neutron with a mean life of 10^3 sec., and the shortest lived is probably the Σ^0-hyperon, the life-time of which, although not yet measured, is expected to be in the neighbourhood of 10^{-19} sec. This example also illustrates the kinds of experiments that must be done in particle physics, and it gives a hint about their difficulty. In order to produce a Λ under controlled conditions, and to observe such a decay mode as $n + \pi^0$, one needs a large accelerator and detectors of considerable refinement. Notice that all the particles are neutral, and so do not produce ionized tracks.

Although the foregoing review constitutes a mere sketch of the high-energy field, it may serve as an adequate background for a short summary of the tenth Rochester Conference. I shall begin with developments concerning the weak interactions. Feynman has looked carefully at the question of universality, with particular attention to the life-time of the muon. Using recent experimental data on the beta decay of oxygen-14, he calculates a muon life-time of $2{\cdot}251 \pm 0{\cdot}012$ μsec. This is slightly longer than the best measured life-time, the discrepancy of about 2 per cent being considerably larger than the combined error. He concludes that the principle as commonly formulated is not quantitative, and he finds further that high-order corrections to the theory only aggravate the discrepancy. Gell-Mann reported on many recent speculations about this general question. He outlined a more abstract formulation of the universality idea, which might be able to cope with the weak interactions of all particles.

Several new experimental results have lent support to other ideas about weak interactions. Ljubimov (Moscow) described an investigation of the 'helicities' of muons in cosmic radiation. According to current theory, the muons in the decay $\pi^+ \rightarrow \mu^+ + \nu$ should spin in the left-handed sense around their direction of motion. The muons from π^- decay should be right-handed. Experiment confirms both predictions. Chuvilo (Dubna) reported on new observations of the decay modes of K^0, and showed that they are in agreement with predictions based on the $\Delta I = \frac{1}{2}$ rule. Additional support for the rule, based on asymmetry measurements in pionic decay of Σ and Λ, was reported by Cronin. It might be said here that none of the many experiments recently carried out has cast any doubt on the invariance principles and selection rules outlined above. With regard to strong interactions, I might first mention the current status of one of the oldest problems in nuclear physics. It concerns the force between nucleons. Early research brought out little more than qualitative facts about the strength and range of the force, without clarifying its details. With the advent of the synchrocyclotron, nucleon scattering could be done at energies up to several hundred MeV. It was discovered that such collisions lead to a strong polarization of the scattered beam, and this phenomenon has become an important tool in the most recent measurements of the interaction. At the conference, representatives of the groups at Harwell, Rochester, Harvard, and Dubna reported that almost all their results now fit into a unique and concise empirical scheme, which it is the aim of theorists to explain. With regard to the theory, one can say that the force at relatively large distances (down to about 3×10^{-13} cm.) is now well understood in terms of a single pion exchange potential. The behaviour at shorter distances, where multiple meson exchange is important, has not yet been dealt with quantitatively.

The strong interactions of K, Λ and Σ particles have also been studied intensively in recent work at the higher energies. The reports from Cornell, Saclay, Brookhaven, Berkeley, Dubna and CERN constitute an enormous library of new data on processes of many different kinds. A particularly interesting result was reported by Good (Wisconsin), who has studied the reaction $K^- + p \rightarrow \Lambda + \pi^- + \pi^+$, and has measured the momentum spectra of the pions. He finds structure in the spectra, suggesting the existence of quasi-stationary states of the $\pi - \Lambda$ system.

Bernardini (CERN) reported progress on the design of experiments for the utilization of energetic neutrino beams derived from the great accelerator in Geneva. It is expected on certain theoretical grounds that the cross-sections for neutrino reactions will be much larger at high energies than they are at low energies. For example, Lee and Yang have speculated about the reaction $\nu + N \rightarrow W + \mu + N$, where W is the hypothetical boson associated with weak interactions. The calculated cross-section for this reaction is 10^{-35} cm.^{2} at high energies; the cross-section for the only neutrino reaction carried out to date ($\bar{\nu} + p \rightarrow e^+ + n$) is 10^{-44} cm.^{2} at low energy.

Another important experiment still in the preparatory stage was described by Panofsky. It will investigate colliding beams of electrons, produced in the Stanford linear accelerator and stored in two magnet rings. The equivalent laboratory energy of the collision will be several thousand BeV., and will in

this sense represent by far the highest controlled energy available to physics. It is hoped that the beams can be used to examine the validity of quantum electrodynamics in an energy region which has so far only been accessible in rare cosmic ray events.

Finally, I shall discuss a report by Heisenberg on progress being made in his theoretical group (Munich) toward the development of a general theory of elementary particles. They assume that the most general symmetry principles of the type summarized above are sufficient to specify a differential equation, the eigenvalues of which are connected with properties of the particles. Thus the symmetry principles rather than the particles themselves are regarded as the elementary notions of physics. A prototype of such theories is the relativistic wave equation proposed thirty years ago by Dirac, who was able to give a deductive account of electron spin and to anticipate the discovery of the positron. Several years ago, Heisenberg and Pauli proposed a non-linear spinor equation to which they were led by symmetry considerations. It appears that, since then, some significant steps have been taken toward illuminating the mathematical properties of the equation and deducing some of its physical consequences. There is as yet, however, no strong experimental evidence for or against the theory. Aside entirely from computational difficulties, the theory is open to certain conceptual objections. One of them stems from the fact that, for the equation to have non-trivial solutions, it must deal with an indefinite metric in Hilbert space. This leads to probability amplitudes of negative norm, for which no interpretation can be given in the usual formulation of quantum mechanics. Heisenberg hopes, however, that all such cases will correspond to virtual states of physical systems, and that negative probabilities may for this reason not be incompatible with the present structure of physics.

It may be clear from this sampling of the conference that the physics of high energies is active on many fronts. It should also be clear that there are fundamental questions still unanswered. Are there still more classes of particles? Are the strict principles of present theory applicable at very small distances and at very high energies? Is there a 'universal' weak interaction, and is there a field quantum associated with it? Are the particles themselves to be regarded as the ultimate entities of physics, or are their properties derivable from a set of simple principles? At any stage in the development of our knowledge there is always a class of questions which seems inaccessible to the methods of physics, but which is nevertheless eventually answered within the context of later developments. It is with a faith strongly supported by this observation that physicists are attacking the provocative questions now before them.

E. M. HAFNER

NEWS and VIEWS

Cloud Physics at the Imperial College of Science and Technology, London: Prof. B. J. Mason

DR. B. J. MASON has been appointed to a newly created chair in cloud physics at the Imperial College of Science and Technology as from October 1960, thus gaining academic recognition for sustained original work in this field over the past decade or so. He joined the Department of Meteorology at the Imperial College of Science and Technology in 1948, following graduation in physics with first-class honours at University College, Nottingham, in 1947 and some research with Dr. G. D. Yarnold on surface tension in the following year. Mason was led to take up research in cloud physics on reaching the Imperial College of Science and Technology, and he soon formed around him an active group of research students concerned mainly with microphysical processes, while his colleague, Dr. F. H. Ludlam, led parallel work on the macrophysics of clouds, to the benefit of the subject as a whole. Cloud microphysics, in Mason's hands, has advanced mainly by his skill in exploiting laboratory techniques and he has designed a number of quite beautiful experiments. Notable among these is the use of the diffusion cloud chamber, in collaboration with Dr. J. Hallett, to determine the forms—needles, plates, prisms, dendrites—in which ice is deposited as a function of temperature and supersaturation. This work has contributed not only to meteorology but, quite notably also, to modern solid-state physics. Mason was awarded the D.Sc. of the University of London in 1956, and was appointed Warren Research Fellow of the Royal Society in 1957. His authoritative text, "The Physics of Clouds", was published in 1957, and he has served on the Councils of the Royal Meteorological Society and the British Association and on Government research committees. Prof. Mason may now, with extra facilities and his noted enthusiasm, be expected to make an increasing impact on the study of cloud physics in Great Britain.

Physics in Hong-Kong: Prof. W. D. Chesterman

DR. W. D. CHESTERMAN has been appointed to the vacant chair of physics in the University of Hong-Kong. Dr. Chesterman graduated at the University of Bristol in 1934. He then became a student apprentice at the British Thomson-Houston Co. and on completion of his apprenticeship was appointed to the staff of the Company, where he remained until 1939, when he joined the Admiralty. His work in the Admiralty has been mainly in the fields of photographic and optical techniques and in underwater acoustics. He became a Fellow of the Institute of Physics in 1943 and of the Physical Society in 1945. During the past ten years he has gained an international reputation for his work on photographic techniques. He has published a book and a number of papers on high-speed photography, which have been very well received. During 1956–58 he was chairman of the International Committee on High Speed Photography, and in 1958 he was elected a Fellow of the Royal Photographic Society. In 1959 he was awarded the degree of doctor of science by the University of Bristol. The papers put forward for his doctorate included published accounts of his work in the fields of underwater acoustics, illumination optics, high-speed photography and oceanographic research.

Parliamentary Secretary to the Minister for Science

In moving the second reading of the Ministers of the Crown (Parliamentary Secretaries) Bill in the House of Commons on November 18, the Financial Secretary to the Treasury, Sir Edward Boyle, said that the Bill was designed first and foremost to give the Government greater flexibility in the deployment of Parliamentary Secretaries between Departments, and also, more specifically, it authorized the payment of a salary, not exceeding £2,500 a year, to a Parliamentary Secretary to the Minister for Science. He would be Parliamentary Secretary to the Minister and not to the Ministry, and if the appointment was made questions falling within the responsibility of the Minister would be answered in the House of Commons by the Parliamentary Secretary. Dr. R. Bennett, speaking as chairman of the Parliamentary and Scientific Committee, welcomed the provision as something for which that Committee had been pressing and also paid a generous tribute to the ability of the present Minister for Science. In replying on the debate, Sir Edward Boyle suggested that provision of a Parliamentary Secretary would assist the Minister to pursue his studies in greater detail and that the Parliamentary Secretary would also be able to reply to debates on all the main subjects for which the Minister was responsible. These responsibilities embraced first the Atomic Energy Authority; secondly, the four main executive research councils; and thirdly, those very important advisory bodies, the Advisory Council on Scientific Policy, with its Scientific Man-power Committee, the Overseas Research Council, and the Steering Group for Space Research. If, on the adjournment, members wished to raise the whole question of the work of the Department of Scientific and Industrial Research, or of the advisory bodies, there would be a junior Minister responsible for replying specifically on these subjects.

British Patents and Designs

On moving the second reading of the Patents and Designs (Renewals, Extensions and Fees) Bill in the House of Lords on November 15, the Earl of Dundee explained that while the Industrial Property Convention of October 1958 made some improvements in existing practice, the only one which needed legislation in Great Britain was the proposed extension from three months to six months in the period of grace allowed for the application for a renewal of a patent or copyright protection for a design. This is done under Clause 1 of the Bill, which also corrects a mistake inadvertently in our own Registered Designs Act but not in the Patents Act of 1949. Clause 2 proposes to repeal the first schedule to the Patents Act, 1949, which specifies certain maximum fees for the registration and renewal of patents but not designs and not trade marks. This schedule to the Act of 1949 is identical with that in the Patents and Designs Act, 1884, and the Earl of Dundee said that it was not proposed to control fees under a statutory instrument as was already done for trade marks or designs, in place of introducing a new schedule. He indicated that if the Bill was passed in its present form the Patent Office proposed to increase the application fee for a patent from £1 to £2, and that for filing the complete specification from £4 to £8. Nearly all the expenses of the Patent Office were in connexion with filing the initial application and the complete specification, and it was proposed to make no increase in the renewal fees, which varied from a maximum of £5 in the first year to £20 in the sixteenth year, and were mostly still less than the set maxima. While welcoming the first part of the Bill, Lord Silkin urged strongly that the clause relating to revised fees should be withdrawn and introduced as a specific single-clause measure, and this was also supported by Lord Cowley and Lord Ferrier, the former of whom thought the present Clause 2 was contrary to the advice of the Swan Committee in 1947. In his reply, the Earl of Dundee maintained that the procedure proposed by the Government was the most advantageous, and said that the Government had already discussed the matter with interested commercial organizations, none of which had raised any objections to the fixing of fees by statutory instruments rather than by a schedule in an act of Parliament.

International Patent Conventions

The Catalogue of the Derwent Information Service describes briefly the various publications and services provided (Derwent Patents Abstracts—Catalogue. Pp. ii+38. London: Derwent Information Service, Theobalds Road, W.C.1, 1960. 2*s*. 6*d*.). These include reports on British, German, Commonwealth, Belgian and Russian patents in certain specified fields, journals containing abstracts of fine chemicals, plastics, petrochemicals and metallurgical patents, and a series of other patents bulletins dealing with more limited fields. Besides information on patenting procedure in various countries, the catalogue includes an article by M. Hyams on Russian patent law and procedure based on discussions with the Committee for Inventions in Moscow.

Museum of Science and Industry, Birmingham

Birmingham City Council recently approved a scheme for extending the Museum of Science and Industry in Newhall Street. The new building will replace old property which is structurally unsound and increase the floor area of the Museum to 150,000 sq. ft. The whole scheme is estimated to cost £590,000 and will take not less than six years to complete. The work of rebuilding will be undertaken in three phases; these comprise the erection of a galleried single-storey unit to house, among other large exhibits, the Pacific locomotive *City of Birmingham*; a six-storey administrative, workshop and stores block and another single-storey unit with galleries, in that order. Provision has been made for a lecture room, two cafés and numerous rest rooms. When the scheme is completed public access will be from Fleet Street (which runs at right angles to Newhall Street) by a bridge over the Birmingham–Fazeley Canal.

The site and buildings now occupied by the Museum were once the premises of Elkington and Co., Ltd. (who are well known for the manufacture of silver-plate), until they were taken over by the Committee of the City Museum and Art Gallery in 1950 to house the newly formed Department of Science and Industry. During the past ten years the old factory has been systematically adapted for Museum purposes and opened to the public as each section was completed. The Museum exhibits small arms, veteran, vintage and modern motor-cars and motor-cycles, machine tools, steam engines which are run periodically on live steam, internal combustion engines and scientific instruments covering a wide field. The annual attendances now exceed 400,000.

Science in France

THE second issue of *French Science News*, published by the French Foreign Office and distributed by its Embassy in London, contains considerable information about major French scientific investigations and developments in science and technology. The main articles are concerned with developments in petrology and astronomy while, among pure research items, summaries of work are given on the fundamental theory of corpuscular systems and the concept of the centre of gravity; ultrasonic absorption and dispersion in polyatomic gases; paramagnetic ion relaxation; the production of tritium in thorium by protons of 135 MeV.; the spectra of conversion electrons and *K* and *L* Auger electrons resulting from the disintegration of thulium-170 to yttrium-170; the basic functions of definite symmetry for the wave-functions of a system of three identical particles; the absorption spectra of selenium and tellurium in ultra-violet light; the equilibrium diagrams of the zircon–oxygen systems of the rare earths; the reactions of the system calcium sulphide–vanadium pentoxide and the preparation and identification of sodium orthonitrates and orthonitrites. Accounts are also given of new developments in apparatus and equipment in various laboratories as well as in engineering. In medicine, details are given of the phosphodiuresis test provoked by parathormone, and the diagnosis of pseudo-hypoparathyroidism in the infant and the risk involved in radiological examinations. Other information includes particulars of new courses at higher education centres, recent books and awards to outstanding men of science. The journal would be considerably improved if the final editing were entrusted to a French-speaking English-born man of science. M. Jean Rostand might then have enjoyed even more his International Kalinga Prize "for scientific Vulgarization . . . for the entirety of his work".

Introducing Pedology

MARIAN RAY, of 36 Villiers Avenue, Surbiton, Surrey, has provided an admirable series of filmstrips showing the origin, composition and use of soil. There are five strips in the series, each of which could form the basis of a lesson to scholars taking the Ordinary Level General Certificate of Education examination in biology, or agricultural students at farm institutes. The first, "Rocks and Erosion", describes the main types of rocks and the action of weathering; the second, "Plants and Decay", is concerned with the elements of plant nutrition and their re-circulation. "Soil Profiles" shows how soil formation is influenced by climate, animals and topography; "Soil Composition" describes the physical and chemical bases of soil; while "Soil and Farming" includes such varied topics as soil erosion, pests and diseases, the effects of teaching crop rotation, the effects of fertilizers, farm machinery and different types of British farming. Each strip is in colour and supported by a booklet with concise text and a short bibliography.

U.K. Population Statistics

THE Registrar General's Quarterly Return for the second quarter of 1960 was published in October. The usual periodical returns show a continuation of the relatively high birth-rate, and it is likely that births in 1960 will exceed the figure of 750,000 registered in 1959 and will be higher than in any year since 1948. Stillbirth and infant mortality-rates continue to decline, and are lower than in any previous corresponding quarter. It is noteworthy that the already low rates have been reduced by 25 per cent during the 1950's. The Return contains an abridged life table for 1957–59, showing an expectation of life at birth of 68·0 years for men and 73·7 for women. The high excess of deaths among males continues, and at ages 55–65 male death-rates were approximately double those of females of the same age. Another table shows the number of years of working life lost per 10,000 population. Among males, cancer, accidents and coronary disease accounted for 40 per cent of the loss; among females, the three most important causes were cancer, bronchitis, and pneumonia and other cardiac diseases (No. 446. Pp. 28. London: H.M. Stationery Office, 1960. 2*s*. net).

Quarterly Journal of the Royal Astronomical Society

THE *Monthly Notices of the Royal Astronomical Society* has hitherto contained both original papers and material primarily concerned with the affairs of the Society. The increasingly specialized character and growing quantity of papers being published in the *Monthly Notices* has led to the appearance of the new *Quarterly Journal* (1, No. 1 (September 1960). Double issue. Pp. 128. 24*s*.; Annual subscription 40*s*.; 6 dollars. Single issues 12*s*.; 1.80 dollars. (London: Royal Astronomical Society.) 1960). It will contain all that was in *Monthly Notices* other than the original papers. Presidential addresses, George Darwin lectures, reports of observatories, and Council notes will be included, together with articles of the type previously appearing in *Occasional Notes*. The latter publication has been terminated. *Monthly Notices* will in future contain only original research papers. The new journal will appear in future in March, June, September and December each year; but, for technical reasons, two double issues are being published in 1960. It will be sent to all subscribers to *Monthly Notices* and to all Fellows of the Society, and will be on sale to others at £2 per annum. The contents of the first issue, dated September 1960, include an address by Prof. R. O. Redman on the work of the Cambridge Observatories, and articles by Prof. F. Hoyle on the origin of the solar nebula and by Dr. B. E. J. Pagel on the surfaces of stars.

The Transvaal Museum, Pretoria

THE report of the Trustees of the Transvaal Museum, Pretoria, for the year ended March 31, 1960, again refers to the shortage of work, storage and exhibition space which prevents the Museum from exercising its proper function to the community (Pp. 46. Pretoria: Transvaal Museum, 1960). The imposition of an entrance fee of 1*s*. led to a decrease of about one-third in the total attendance. On the other hand, it has eliminated the disinterested and undesirable visitor who formerly used the Museum as a rest-house and caused much trouble. Two major expeditions to the Gobabeb area of the Namib Desert and Somalia have been organized during the year. The former was made possible by a generous private donation and produced much material and information concerning life under extreme desert conditions.

Fulbright Travel Grant:

Under the provisions of the Fulbright programme, travel grants are available to citizens of the United Kingdom and dependent territories, to go to the United States for an academic or educational purpose, provided that they have adequate financial support in dollars for the visit, and have been accepted by an American institution of higher learning. Grants cover the cost of direct travel between a candidate's home and the American university or institution. They are available during June 1–August 15, 1961, for which application must be received by March 15, 1961; and August 16, 1961–April 1, 1962, for which applications must be received by June 1, 1961. Application forms and further information can be obtained from the United States Educational Commission in the United Kingdom, 71 South Audley Street, London, W.1.

"McGraw-Hill Encyclopedia of Science and Technology"

The McGraw-Hill Publishing Co., Ltd., has just published a 15-volume "Encyclopedia of Science and Technology". It is of handy format, each volume consisting of 600–700 double-column pages, and the last volume includes an index to the whole. It is claimed that the work involves 7,200 articles, varying in length from 100 to 1,500 words, contributed by more than 2,000 scientists and technologists from the United States, among whom are many with an international reputation. Continuous revision, the bugbear of any form of encyclopædia, is to be provided by means of "Year Books", beginning in 1962, each consisting of articles on outstanding developments of the preceding year, and shorter notes on important discoveries, new products and applications. The prepublication price is £61 11*s.* 6*d.* (159 dollars); after December 15 the price will be £67 16*s.* 6*d.* (175 dollars).

University News:

Birmingham

The following appointments have been made: *lectureships*, Dr. C. F. Wells (chemistry), Dr. F. Bakhtar (mechanical engineering), Dr. J. L. Jinks (honorary lecturer in the Department of Genetics); *research associateships and fellowships*, G. Lines (medical biochemistry and pharmacology), P. Johnson (medical biochemistry and pharmacology), R. H. Hollier (Tube Investments Senior Research Fellow in the Department of Engineering Production), G. R. Izaak (nuclear physics).

The University has accepted the offer by Joseph Lucas, Ltd., to second to the University each year an American professor, nominated by the University, to hold a Joseph Lucas visiting professorship in the Department of Engineering Production.

Leeds

Dr. H. M. N. H. Irving, of the University of Oxford, has been appointed to the chair of inorganic and structural chemistry, from a date to be arranged.

London

Prof. B. G. Neal, professor of civil engineering at the University College of Swansea, has been appointed to the University chair of applied science with special reference to engineering tenable at the Imperial College of Science and Technology.

Sheffield

Among the appointments to be announced recently are the following: N. Moray, to be lecturer in psychology; J. E. Enderby, to be lecturer in physics; Dr. J. V. S. Mani, to be I.C.I. Research Fellow in the Department of Fuel Technology and Chemical Engineering.

Sydney

Dr. W. N. Christiansen has been appointed to the Peter Nicol Russell chair of electrical engineering in succession to Prof. D. Myers. For twelve years prior to his appointment he was engaged in research on radio astronomy in the Commonwealth Scientific and Industrial Research Organization. Dr. L. C. Birch has been appointed to the Challis chair of zoology, which became vacant on the retirement early this year of Prof. P. D. F. Murray. Dr. Birch was appointed to a senior lectureship at the University in 1948 and later became reader in zoology.

Announcements

Viscount Amory has been appointed chairman of the Medical Research Council, in succession to the Earl of Limerick.

Dr. George W. Corner, For. Mem. R.S., historian of the Rockefeller Institute, New York, and director emeritus, Department of Embryology of the Carnegie Institution of Washington, has been appointed executive officer of the American Philosophical Society, Philadelphia. He will retain a connexion with the Rockefeller Institute as visiting professor.

The third international symposium on "Comparative Endocrinology" is being sponsored by the Zoological Society of Japan, and is to be held during June 5–10, 1961, at Oiso. Further information can be obtained from the chairman of the symposium, Dr. Kiyoshi Takewaki, Department of Zoology, University of Tokyo.

An international pharmacological meeting is being organized under the auspices of the Section of Pharmacology of the International Union of Physiological Sciences, and is to be held in Stockholm during August 22–25, 1961. The general theme of the meeting will be "Mode of Action of Drugs". Further information can be obtained from the First International Pharmacological Meeting, Karolinska Institutet, Stockholm 60, Sweden.

"New Polish Publications" lists new and forthcoming books published in Poland, with annotations in English. The books of scientific interest are classified under the headings: philosophy, psychology, education; economics, social sciences; biology; agriculture, forestry; medicine; mathematics, astronomy, chemistry; geology, geography, geophysics; and techniques. Issues Nos. 1–5, 1960, include some 126 entries under these headings (Agpol Foreign Trade, Advertising and Publishing Agency, Warsaw).

Under the title "United Kingdom Postgraduate Awards 1960–62" the Association of Universities of the British Commonwealth has issued a list of such awards tenable at universities in the United Kingdom, and a short list of awards for United Kingdom graduates tenable at universities outside the United Kingdom (Tenth Edition. Pp. ii+136. London: Association of Universities of the British Commonwealth, 1960). There are a subject index to each list and also an index to the named awards. This tenth edition is in a new and larger format, and it is proposed to publish subsequent editions every two years.

HIGH-VOLTAGE ACCELERATORS

As attendance at international conferences tends to become larger and the programmes more congested, there is an unfortunate tendency for papers to become shorter and more specialized, so that the proceedings of such conferences are largely unintelligible to workers outside a narrow field. In fact, many of the short papers contributed to such meetings present detailed experimental data which arouse little discussion and would be more adequately dealt with by straight publication in journals of the learned societies. An entirely different situation occurs in meetings where the number of papers is limited, and adequate time is available for experts in neighbouring fields to present a more general review of present status, tendencies and difficulties in their respective subjects. With adequate time for discussion, attendance at such meetings can be very profitable not only by allowing informal interchanges between specialists but also by providing others with a feeling for the prevailing current of thinking in each subject, which cannot be obtained by reading the specialist literature.

The advantages of this second type of conference were brought out very clearly at the second Accelerator Conference which was held during October 4–6 at the Krasnapolsky Hotel, Amsterdam. Sponsored by the High Voltage Engineering Co., this meeting brought together more than three hundred scientists from twenty-four countries, either designing or using high-voltage accelerators for a variety of scientific purposes. A total of twenty-two lectures was given, and these brought out strongly the wide range of studies in which such accelerators have become essential. The session on the first day was devoted to applications in nuclear physics; the second to the new tandem accelerators and the types of experiments on which these are now used. Separate sessions on the morning of the third day were devoted to varied topics in neutron physics, isotopes separation, activation analysis, solid state research. The concluding session in the afternoon of the third day outlined contributions in radiobiology, industrial and medical applications and future accelerators for high-power applications.

A major feature of many of the lectures and ensuing informal discussions was the interchange of views on future applications and requirements for high-voltage accelerators. In many nuclear physics problems, highly monochromatic beams of very short duration are needed, whereas for industrial applications lower voltages and less-uniform beams are quite acceptable if the cost per kW.hr. could be reduced. In this connexion the forecasts of accelerator designers are most encouraging. Already the cost has sunk to between 2 and 10 dollars per kilowatt for a 10-kW. machine. With re-design, longer life of components and higher output ratings, we may expect to obtain high-voltage radiation at a total cost of less than 1 dollar per kW.hr., and 5,000 dollars per kW. installed. Although these figures are high compared with electrical energy from 240-V. mains supply, they are very favourable when related to the costs from electrical accelerators at present installed, or the present cost of radioactive isotopes such as cobalt-60. A single accelerator producing 20 kW. of high-energy radiation has the same energy output as several million curies of cæsium-137, which is far greater than the total world production from fission products. Since one kW.hr. of high-energy radiation, if fully absorbed, can give a sterilizing dose of 2·5 megarads to 300 lb. of material, the cost of radiation is no longer an economic handicap in a number of industrial processes. Attempts to discover industrial applications for high-energy radiation have been carried out in a number of industrial laboratories. It is unfortunate that for commercial reasons the more successful applications have not so far received much publicity. The paper contributed by S. H. Pinner and W. H. T. Davison gives an interesting compilation of patents involving radiation which have already been published. These indicate clearly the considerable interest in the polymer field, where a large change can be obtained with a relatively modest radiation dose.

On the nuclear physics side, Prof. P. M. Endt (Utrecht) discussed the use of proton- and gamma-rays in the study of nuclear resonance-levels, and Dr. T. Huus (Copenhagen) summarized work on Coulomb excitation. Prof. L. Katz (Saskatchewan) diverged from his original script to outline his requirement for a research linear accelerator. On the premise that he was only allowed one such equipment for research he laid down the very stringent specification required. The scientists and designers concerned with accelerator design were prepared to meet this technical challenge if the physicists undertake responsibility for finding the necessary money. It was not clear how the many earnest seekers after scientific truth could all congregate at the feet of this valuable, but extremely expensive, oracle.

By using ultra-fast microwave pulse techniques, lifetime measurements of the order of 7×10^{-11} sec. were determined in some odd argon rare earth nuclei by Dr. G. Goldring (Rehovoth). Dr. E. Cotton (Saclay) also gave a short review on nuclear widths and life-times and Dr. A. Schoch (CERN, Geneva) discussed colliding beam techniques.

Electrostatic machines have considerable advantage in the production of continuous beams, and the voltage can be readily adjusted, but there is a limit of roughly 5 MeV. beyond which they cannot operate satisfactorily. This limit had been overcome by the use of tandem generators in which negative ions are accelerated from earth potential to about this voltage, then stripped to give positive ions which continue their path in the same direction. By this means the energy of the beam is doubled. The first of these new tandem generators was installed at Chalk River in February 1959, and Dr. H. Gove (Atomic Energy of Canada, Ltd.) gave details of experiments with this new equipment. In spite of its novel character 80 per cent operational time has been attained with a two-shift programme. The problems studied include proton cross-sections, giant resonance in carbon-14 and silicon-28, and thresholds and yields, departures from Rutherford scattering and narrow resonance structure. Dr. K. W. Allen (Atomic Weapons Research Establishment) also dealt with the advantage of a tandem generator as compared with the

linear accelerator or the betatron for their nuclear work, which involves bombardment with p, d, t and ^{3}He ions in the energy-range of up to 10–12 MeV. and direct measurement of nuclear life-times of 10^{-11}–10^{-14} sec.

There is an obvious need for accelerators going to even higher voltages, and Dr. P. Rose (High Voltage Engineering Co.) described plans for three-stage accelerators giving 15 MeV. He also foresaw accelerators furnishing 30-MeV. beams of 10 m.amp. within ten years. Other potential improvements in high-voltage accelerators include millimicrosecond pulsing as compared with the 2-μsec. pulse at present available (R. Connor, High Voltage Engineering Co.) and more powerful generators using the 'Amplitron' instead of the klystron or magnetron (J. C. Nygard, High-Voltage Engineering Co., and R. F. Post, California).

Ion sources of high efficiency, capable of separating μgm. quantities of rare materials, were described by Prof. J. Kistemaker (Amsterdam), while Prof. R. Fleischmann (Erlangen) discussed polarized ion beams, and Dr. K. Beckurts (Karlsruhe) dealt with pulsed neutron sources and neutron life-time in moderators.

In radiation research, high-voltage beams are valuable in solid-state investigations, as outlined by Dr. P. Baruch (Paris) and have also been used in chemical analysis, either by gamma or neutron activation (J. W. Otvos, Emeryville). Radiation effects in biological systems, as presented by Dr. W. Huber (Stanford), particularly emphasized aspects of interest to radiation physicists and chemists dealing with radiation damage in much simpler systems.

The time-scale permitted adequate time for private discussions on many specific aspects which could not be raised at the formal sessions. Social activities included a banquet given by the High Voltage Engineering Co., at which Prof. H. B. G. Casimir of the Philips Research Laboratories delivered a witty speech and a reception was held by the Mayor and Aldermen of Amsterdam. This included a Van Gogh exhibition which was very much appreciated. Scientific education is sometimes described as narrow and non-cultural. Perhaps we may hope that students of the humanities who hold this view also relax from their learned meetings by attending exhibitions of classical scientific experiments and reading or discussing recent developments in atomic structure, relativity and quantum theory, the basic concepts of which have an increasingly important influence on the outlook of the modern thinking man.

The full proceedings of the conference will be published at the end of the year in *Nuclear Instruments and Methods*.

A. Charlesby

FLOW MEASUREMENT IN CLOSED CONDUITS

Flow measurement is one of the less-spectacular aspects of fluid dynamics, and perhaps for this reason it has not received the attention it deserves. Nevertheless, flow-metering is as old as the engineering applications of fluid dynamics, since in almost every application it is desirable or important to know the volume or mass flow per unit time passing through the system. For example, the distribution of water in a water grid, the flow of air in an air-conditioning plant, the supply of steam to a turbine, the regulation of the flows in the continuous production of chemical engineering products. The fluids may be gases or liquids and the latter may be corrosive or contain solid suspensions as in sewage or wood pulp. The rate of flow may be small as in a blood vessel or great as in large hydraulic turbine installations and in gas turbines. The nature of the fluid, the size of installation, the speed of flow and the accuracy required, all influence the choice of meter.

Of the more common types of flow-meter, the simplest and most accurate for measurements in liquids consists of a large vessel on a weighbridge into which a given mass of liquid is timed. The National Engineering Laboratory, East Kilbride, possesses a 30-ton weighing tank. Alternatively, a somewhat less accurate but more convenient method is that which uses a vessel designed on the pipette principle, into which a definite volume of liquid is timed. These two methods are generally used as standards against which more compact and convenient flow-meters may be calibrated. The pitot-static pressure head has been widely investigated, and used by aerodynamicists for measuring the velocity at a point in air flows, and is regarded by them as a fundamental instrument. By traversing the instrument across a duct the velocity distribution and hence the flux can be found. Small rotating vanes coupled to counting devices and known as current meters can also be used to find the velocity at a point after calibration, and hence the volume flow can be found by integration. A great many meters in practical use utilize a pressure difference brought about by a change of cross-sectional area of the duct. In nozzles and venturi meters this change of area is smooth and gradual, and such meters introduce little loss into the duct system, but they are fairly sensitive to upstream disturbances. In the orifice-plate type of meter the change of section is sudden, and a large resistance is offered to the flow, which gives rise to a large pressure difference. Another method, used in hydraulic power installations, involves the steady injection of a solution of salt at a known rate. Samples are then taken downstream where the mixing is complete, and from the dilution the mass flow can be found. A variant of this makes use of radio-active isotopes. Some methods attempt to measure the mass or volume flow directly without introducing any obstruction into the duct. An interesting example is the magnetic flow-meter, in which a magnetic flux is set up at right angles to the flow of a conducting liquid, and a current flows between two electrodes in the pipe wall which can be related to the volume rate-of-flow. The meter is of particular value in water-borne sludges. Another example of considerable practical importance is the Gibson method. In this the fairly rapid closure of a valve, or of the inlet guide vanes of a hydraulic turbine, causes a pressure variation with time between two stations in the pipe line. The integral of this over the time of closure is related closely to the

destruction of momentum and so to the mass-rate of flow.

During September 27–30 a symposium on "Flow Measurement in Closed Conduits" was held in the new James Watt building of the National Engineering Laboratory. It was the first of a series which are to be held there, and so far as can be discovered, it was the first symposium devoted solely to flow measurement which has been held anywhere. Some 150 delegates were present; about 50 coming from countries of Western Europe, the United States and the Dominions and the remainder from British manufacturers, industrial users, official establishments and universities. The symposium occupied four days, and on the last evening the delegates attended a dinner at the Central Hotel, Glasgow, given by the director, Dr. D. G. Sopwith, to the authors of the papers. On the last afternoon, the delegates were invited to look around the various laboratories of the National Engineering Laboratory.

Dr. Sopwith was chairman at the opening session when the first item was the presentation of a film made by the National Engineering Laboratory at the Kinlochleven power-station, showing the comparative testing of a number of flow-meters. This was followed by the 'opening address' given by Vice-Admiral Sir Frank Mason, chairman of the Steering Committee of the National Engineering Laboratory. The remaining six sessions were devoted to the discussion of twenty-nine papers.

Session *A* was concerned with current meters and pitot tubes, and included contributions from the United States (1), Italy (1), France (2), and the United Kingdom (2). Session *B* discussed orifice plates, with papers from the United States (1), United Kingdom (2), France (1). Venturi-meters formed the subject of Session *C*, with papers from the United States (1), Belgium (2), and the United Kingdom (1). Session *D* dealt with the various other pressure difference devices, with contributions from the United Kingdom (2), West Germany (1), Austria (1), and the United States (1). Session *E* was devoted to salt dilution and salt velocity methods, with papers from the United States (1), France (1) and the United Kingdom (2). Session *F* discussed the Gibson method, with papers from Norway (1), and the United Kingdom (1). Session *G* was concerned with special methods, and papers were presented from the United Kingdom (3), West Germany and Holland (1). All papers were in English and the discussions were in English, and though translator services were available these were required but once. The papers and the discussions are to be published as a bound volume. The excellent organization of the symposium by the deputy director, Dr. Hutton, and by Dr. Winternitz and his staff of the Fluid Mechanics Division of the National Engineering Laboratory, ensured that the maximum time was available for the discussion of the papers. The discussions were frank and helpful and were enlivened by certain overseas visitors with a nice sense of humour.

The theme of most of the papers and the discussions was the question of accuracy or constancy of the calibration coefficient. This is a very important feature of any flow-meter, and it was clear from the papers that considerable effort is being made to improve existing flow-meters in this respect. Present-day standards of accuracy for most flow-meters fall far short of those for physical measurements; for example, a reliable accuracy of 1 per cent must be regarded as rare. There are good reasons for this, since most flow-meters are affected by scale effects (Reynolds number), effects arising from upstream installations, such as bends and changes of section, turbulence and compressibility (in the case of gases), by erosion, corrosion and solid deposits which can cause deterioration with time. This question of accuracy is, in many cases, of great practical importance. In chemical engineering, accurate metering and regulation of the flow of the various products in continuous-flow processes is desirable on both technical and economic grounds. The manufacturers of pumps and turbines are frequently called on (in the case of large units) to meet very stringent performance specifications, which involve quantity flow, and it is essential that the manufacturer and the user should agree on the flow-metering accuracy. Since many countries export turbo-machinery, flow-metering has an international importance. One of the important results achieved by the symposium was not only the bringing together of the manufacturers, users and research workers, but also the achieving of this on an international level, so that a wide variety of experience was pooled and important personal contacts were made.

In conclusion, therefore, it can be stated that the symposium was timely and a great success, due mainly to the excellent arrangements made by the Fluid Mechanics Division of the National Engineering Laboratory.

J. H. PRESTON

PROGRESS IN CALORIMETRY

THE fifteenth annual Calorimetry Conference was held at Gatlinburg, Tennessee, during September 7–10, with Oak Ridge National Laboratory acting as host and Dr. J. P. McCullough (Petroleum Thermodynamics Laboratory, Bureau of Mines) serving as chairman. In the pleasant surroundings of the Great Smoky Mountains, 106 calorimetrists from the United States, Canada and Europe heard and discussed thirty-one technical papers on recent work on many phases of calorimetry and engaged in informal discussions of calorimetric problems. Among the topics discussed were calorimetry at temperatures as low as 0·1° K. and as high as 2,800° K., precision reaction and bomb calorimetry, solution calorimetry, applications of calorimetry to solid-state problems, application of calorimetry to radiation dosimetry, improvements in temperature measuring devices, and data processing by digital computers. At the Conference banquet, Dr. A. M. Weinberg, director of Oak Ridge National Laboratory, shared his experiences and observations on a recent trip to the U.S.S.R. with the chairman of the U.S. Atomic Energy Commission, illustrating his talk with a number of interesting slides. Dr. D. W. Osborne

(Argonne National Laboratory) was programme chairman, and Dr. R. H. Busey (Oak Ridge National Laboratory) was local arrangements chairman.

The Hugh M. Huffman Memorial Lecture, established in memory of the founder of the Calorimetry Conference, was given by Prof. J. W. Stout (University of Chicago) on the subject "Magnetic Entropy in Ionic Crystals". Prof. Stout gave a stimulating lecture on the magnetic contribution to the entropy of ionic salts of the transition metals, discussing the theoretical considerations and the results obtained from low-temperature heat-capacity measurements and from experiments on magnetic susceptibility, paramagnetic resonance, and optical absorption.

Several papers were devoted to a perennial concern of the Conference: the improvement of temperature-measuring devices. Further tests of the germanium resistance thermometers developed at the Bell Telephone Laboratories were described, with H. Plump reporting on "Low Temperature Thermometry at the National Bureau of Standards" in the range 2–20° K., and C. van Rijn, H. van Dijk and M. Durieux (Kamerlingh Onnes Laboratorium, Leyden) reporting on "Calibration of a Germanium Resistance Thermometer at Liquid Helium and Liquid Hydrogen Temperatures". These devices show such encouraging promise for precision temperature measurements from 1° to 20° K. that a committee has been seeking a manufacturer of additional germanium thermometers for further testing. P. Lindenfeld (Rutgers University), chairman of the committee, reported that the Minneapolis-Honeywell Regulator Co. has become interested, and G. Halverson of that Company showed several pilot models.

Results in a quite different temperature region were presented by J. P. Evans (National Bureau of Standards), who described the development of platinum resistance thermometers for the International Temperature Scale from 630·5° to 1,063° C. It is expected that the use of such thermometers will simplify and smooth the scale, as well as provide greater precision and reproducibility than is possible with present thermometric instruments. Also, the use of thermistors for measuring small changes of temperature in solution calorimetry was described in several papers. A notable example was the paper by G. R. Argue, E. E. Mercer, and J. W. Cobble (Purdue University) on "An Ultrasensitive Thermistor Microcalorimeter" for the determination of the heats of solution of the heavy elements with quantities as small as 5 or 10 μgm.

Several authors reported on applications of calorimetric techniques to solid-state physics. J. E. Kunzler (Bell Telephone Laboratories), for example, discussed methods for the observation of very small amounts of energy—between 10^{-2} and 10^{2} ergs—and the application of these techniques to investigations of magneto-thermal oscillations of single crystals of bismuth and the adiabatic demagnetization and heat capacity of ferrimagnets.

A subject of great interest to calorimetrists measuring or analysing heat capacities was presented by B. N. Brockhouse (Atomic Energy of Canada, Ltd.) in an invited paper on "Dispersion Curves and Frequency Distributions of Lattice Vibrations from Neutron Scattering". A novel cryostat for low-temperature calorimetry from 4° to 80° K. was described by V. Mathot (Free University of Brussels), along with experimental results on the heat of mixing of hydrogen and deuterium liquids. Another interesting new type of cryostat, a helium-3 cryostat with a lead wire thermal switch for cooling the calorimeter to 0·3° K., was depicted by D. L. Martin (National Research Council of Canada).

The Conference is deeply interested in the adequate presentation of calorimetric and thermodynamic data. For this reason the fifteenth Calorimetry Conference considered carefully and adopted a "Resolution on Publication of Calorimetric and Thermodynamic Data" which is intended to be a guide for authors, editors and referees of calorimetric papers. This resolution is a revision of one adopted in 1953 that has been valuable to authors and editors alike.

Plans were announced for the next conference, which will be an International Calorimetry Conference and will be held at Ottawa during August 14–17, 1961. The meeting will be jointly sponsored by the Calorimetry Conference and by the Subcommission on Experimental Thermochemistry of the Commission on Chemical Thermodynamics of the International Union of Pure and Applied Chemistry. The host organization will be the National Research Council of Canada.

At the annual election the following officers were elected: *chairman*, Dr. D. W. Osborne (Argonne National Laboratory); *chairman-elect*, Dr. J. E. Kunzler (Bell Telephone Laboratories); *secretary-treasurer*, 1960–63, Dr. G. T. Furukawa (National Bureau of Standards); *directors*, 1960–62, Dr. G. T. Armstrong (National Bureau of Standards) and Dr. J. K. Logan (Naval Research Laboratory). Other directors of the Conference are: Dr. J. P. McCullough, Prof. David White (Ohio State University), Prof. N. E. Phillips (University of California, Berkeley), and Prof. J. M. Sturtevant (Yale University).

THE INTERNATIONAL ASSOCIATION OF VOLCANOLOGY

THE International Association of Volcanology, under the ægis of the International Union of Geodesy and Geophysics, met in Helsinki during July 25–August 6, with Prof. A. Rittmann, who is a Swiss citizen, as president.

Mr. G. R. Laclavére, in his capacity as interim secretary in place of Prof. F. Signore, who died on December 2, 1959, reported that since the last general assembly in Toronto in 1957, five parts of the *Bulletin Volcanologique* and six parts of the Catalogue of Active Volcanoes (Africa, Melanesia, Central America, Kurile Islands, Kamchatka and the U.S.A.) had been published, and in September 1958 fifty-four volcanologists, from twelve countries, had met in Paris for a symposium.

In Helsinki, under the presidency of Prof. A. Rittmann, and with the assistance of the local secretary, Prof. Th. G. Sahama, the work of the Association was arranged in four sections: (1) active volcanoes (six papers and six reports); (2) physics of volcanoes

(four papers, also five papers combined with section 1); (3) physical chemistry and chemistry of magmas, volcanic waters and volcanic gases (eighteen papers); (4) palæovolcanology and plutonism (fourteen papers).

Altogether fifty-five contributions were submitted to the Association from fourteen countries, distributed as follows: U.S.S.R. 15, United States 8, France 6, Japan 6, Australia 4, Great Britain 4, Belgium, Italy, Portugal and Switzerland 2 each, India, Mexico, Netherlands and Norway 1 each. Of these contributions forty-three were read and discussed. In addition, two papers on lunar volcanoes were submitted. Prof. A. Rittmann's presidential address dealt with the geochemistry of basalts and the mechanism of their eruption. The national reports on recent volcanic activity were contributed by Australia, India, Japan, Mexico, United States, U.S.S.R.

Several joint symposia also were held on the subjects of: (1) isotope geology and experimental petrology; (2) the age of minerals, Pre-Cambrian rocks and meteorites; (3) island arcs and the ocean floor.

Two discussions were held under the combined auspices of the International Association of Volcanology, the International Association of Seismology and the Geochemical Commission of the International Union of Pure and Applied Chemistry, on the question of the position of geochemistry within the International Union of Geodesy and Geophysics and other international scientific unions. As a result, a request was made to the Council of the International Union of Geodesy and Geophysics for the establishment of an *ad hoc* committee on 'Geochemical Problems'. The function of the committee would be: (1) to arrange meetings in the field of geochemistry under the auspices of the committee, or under the joint sponsorship of the committee and other sections of the Union; (2) to promote the furtherance of geochemistry by investigating the possibility of a relationship between the International Union of Geodesy and Geophysics, the International Union of Pure and Applied Chemistry, and any other international body in the field of geology which may be formed.

During the Assembly two volcanological colour films of outstanding interest were shown, illustrating a spectacular basaltic eruption in Hawaii, and also the remarkable achievements of the Belgian expedition which recently studied the lake of molten lava far down in the crater of the Congolese volcano Nyiragongo.

The president, Prof. A. Rittmann (Catania University), announced a decision, taken jointly by the Department of Volcanology of Catania University in Sicily and the Belgian National Centre of Volcanology, to explore the possibility of creating an International Institution for Volcanological Research in Catania, close to Etna.

The Association expressed approval of the Executive Committee's plan to hold two symposia before the next General Assembly, the first to be on the formation of ignimbrites, hyaloclastites and related deposits, and to be held in Catania during October 1961, and the second on the prediction of time and place of volcanic eruptions and the relationship between magmas and the nature of volcanic eruptions, to be held in Tokyo (Japan) during May–June 1962.

The Association also approved the proposal that a *Bulletin of Volcanic Eruptions* should be instituted. Such a publication, recording briefly current volcanic phenomena, should appear up to four times a year, and it should be distributed to National Sub-Committees for Volcanology and to certain individuals. It is anticipated that the Volcanological Society of Japan will agree to undertake and finance publication and distribution.

Office bearers for the triennium 1960–63 were elected as follows: *president*, Prof. A. Rittmann (Switzerland); *vice-presidents*, Prof. V. I. Vlodavetz (U.S.S.R.) and Mr. Gordon A. Macdonald (United States); *secretary*, Prof. F. Penta (Italy); *chairman of Section I*, Dr. M. Neumann van Padang (Netherlands); *chairman of Section II*, Dr. G. S. Gorshkov (U.S.S.R.); *chairman of Section III*, Prof. H. Kuno (Japan); *chairman of Section IV*, Prof. B. Gèze (France).

UNIVERSITY DEVELOPMENT IN BRITAIN

THE statement issued by the Association of University Teachers on the problems of university development is one which should be carefully studied by all who are concerned with policy-making in this vitally important field*.

The Association is concerned about the arbitrary way the University Grants Committee has recommended that university expansion should cater for two scientists against one entrant for all other faculties, including medicine and agriculture, and asks that this matter be reconsidered.

Agreeing with the University Grants Committee's estimate that the number of university students in Britain by 1970 should be about 170,000, the Association believes that present standards of entrance to the university should be maintained, and is of the opinion that there should be sufficient applicants of quality to maintain that standard for at least 170,000 places, and that this figure may have to be exceeded.

To cater for the additional 70,000 students for whom places will have to be found in the next ten years, a major operation will be required. This can be done by increasing the size of existing universities or by founding new ones. Recognizing all the attendant dangers to institutions which grow too large, the Association recommends that at least six new universities should be started during the next two years.

The arguments for new universities are strong. Their building cost can be shown to be no greater than that of expanding existing universities, while the difficulty and cost of acquiring land must be less. The contribution that they can make in terms of variations in teaching methods and added range of research is considerable. There should be a deliberate

* "Some Problems of University Development". Pp. 7. (London: Association of University Teachers, 21 Dawson Place, W.2, 1960.) 1*s.* 6*d.*

policy of preserving the pattern of university life to be found in the smaller and medium-sized universities; this cannot be achieved without creating new universities.

It has been argued that because new universities have to be created and built, no appreciable contribution can result during the next decade. The Association believes that this depends on the urgency of the approach to the problem.

The Association makes a clear recommendation that new universities should be planned from the beginning for what is regarded as their likely size. Thus, a university planned for 3,000–3,500 should start with the appropriate building plans, which may be phased but should not require subsequent revision. A maximum of 4,500 should leave ample scope for later expansion to accommodate whatever specialism an individual university may adopt. The new campus should be built with all the buildings going up simultaneously. The intake in each of the first three years might be 750–800 undergraduates, building up in the three following years to 900, leaving the balance for postgraduate places. To do this requires an approach to planning and construction comparable with large industrial organizations.

The planning of the university itself as a centre of research and learning should be approached in an equally dynamic fashion. There is no time for a consultative committee to work out the charter for each university and its range of subjects. The experience gained in the creation of universities in North Staffordshire and at Brighton should be drawn on immediately, and a draft charter should be devised for each university which would be expressed in terms allowing a flexible approach by the universities concerned, and each such charter should be revised at the end of ten years.

To meet the urgency of the situation, it is suggested that the vice-chancellor, the deans of faculties, the librarian and the senior administrative officers be appointed immediately the university is created, the heads of departments should be appointed eighteen months before the first students are admitted, and other staff should be recruited during the ensuing period. An approach of this nature would enable a university to open its doors four years after the decision to create it, and seven years from the decision being taken one could expect to find 2,500 students in residence, and 3,000 ten years later. If this procedure were followed for six or more new universities, there would be a solution to the likely balance of demand before the end of the 1960's.

The Association believes that the new universities should be located in towns with not less than 50,000–100,000 population. They should be broadly based, and not of the character of either a liberal arts college or a two-faculty university. There should be opportunities for the individual development of rarer faculties. In each there should be found arts, social science, science and applied science. The applied sciences should be linked with the region in which the university is established.

GENERAL RELATIVITY AND LORENTZ-INVARIANT THEORIES OF GRAVITATIONS

By Dr. G. J. WHITROW and Dr. G. E. MORDUCH
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DESPITE the initial successes of Einstein's general theory of relativity, attempts to produce a satisfactory Lorentz-invariant theory of gravitation have persisted until the present day. The three well-known Einstein tests are all obtained from the Schwarzschild metric, that is the general relativity solution of the one-body problem. There has been no direct confirmation of the field equations of the theory; but in time it should prove possible to test the results of the two-body problem in the theory as far as terms of order $1/c^3$.

Although more cogent in its æsthetic and general intellectual appeal than rival theories, general relativity is not unique in the results it predicts for the motion of perihelion, deflexion of light-rays and gravitational red-shift in the one-body problem. The same results are obtained in some Lorentz-invariant theories of gravitation. No general analysis has previously been made of these theories, nor have the results predicted by them been systematically compared with the corresponding formulæ derived from general relativity. We have therefore recently made a thorough review of Lorentz-invariant theories, and the details of our analysis will be published later. It is the object of the present communication to present our principal conclusions.

We have considered seven possible tests in all: the three well-known tests obtained for the one-body problem; the secular acceleration of the centre of mass and the advance of periastron in the two-body problem; and the two additional effects introduced into the one-body problem when the axial rotation of the central body is taken into account. The formulæ for these effects have all been obtained previously in general relativity, at least to order $1/c^3$. Corresponding formulæ for some of these effects have previously been obtained in some Lorentz-invariant theories. We have derived the required formulæ for all the theories that we have considered.

Before setting out the comparative tables of results, we must explain our method of classifying Lorentz-invariant theories, which includes some not previously discussed. Attention is, of course, restricted to theories which satisfy the condition that they reduce to the Newtonian form when c is replaced by infinity. (The basic reason for seeking to replace the Newtonian theory of gravitation is that the theory is applicable only when c can be taken as effectively infinite.) First we consider in turn theories in which the gravitational potential is (i) a scalar, (ii) a vector and (iii) a second-order tensor.

Scalar Theories

Under this heading, we consider Nordström's theory[1] and a generalization which includes as special cases theories due to D. E. Littlewood[2] and O. Bergmann[3]. In this generalization Laplace's operator in Poisson's equation for the potential φ is replaced by D'Alembert's operator, and the equations of motion are obtained from the variational principle:

$$\delta \int \exp\{-f(\varphi/c^2)\}ds = 0$$

where ds^2 is the Minkowski metric, and:

$$f(x) = x + qx^2 + \ldots$$

Nordström's own theory is given by $f(x) = x$, whereas Littlewood's and Bergmann's theories, although derived from different initial assumptions, are both given by $f(x) = -\log(1-x)$

A different type of scalar theory, associated with a uniformly expanding world-model, was devised by E. A. Milne[4] and considered further by G. L. Camm[5], G. J. Whitrow[6], A. G. Walker[7] and W. S. Krogdahl[8]. In this theory the mutual potential energy of a particle of mass m_1 at x_1^a ($a = 1, 2, 3$) at time t_1 and a particle of mass m_2 at x_2^a at time t_2 is given by:

$$-\frac{m_1 m_2 c^2}{M_o}\frac{X_{12}}{(X_{12}^2 - X_{11}X_{22})^{1/2}}$$

where $X_{rs} = t_r t_s - x_r^a x_s^a/c^2$, $M_o = c^3 t/G$, t being the present epoch and G the constant of gravitation. The condition $X_{11} = X_{22}$ is imposed.

In all these theories it is assumed that the velocity of light c is a constant. We have, in addition, considered two types of scalar theory involving a variable velocity of light (function of the field):

(i) derived from the variational principle:

$$\delta \int ds = 0$$

where $ds^2 = c^2dt^2 - dx^a dx^a$. (This leads to the same equations of motion as were obtained in 1912 by Einstein[9].)

(ii) Derived from the variational principle:

$$\delta \int \exp(-\psi/c^2)ds = 0$$

where $ds^2 = dt^2 - dx^a dx^a/c^2$, ψ satisfies the modified Poisson equation (with D'Alembert's operator), and $c^2 + 2\psi =$ constant. (This is of Nordström's form, except that c is now a function of the field.)

Vector Theories

Under this heading, we have examined first a generalized Maxwell type of theory not previously considered in which the vector potential φ^a ($\alpha = 0, 1, 2, 3$) satisfies the equations:

$$\Box\varphi^a = 4\pi\frac{G\rho}{c^2}\frac{dx^a}{ds}$$

where $\Box$ denotes D'Alembert's operator, ρ is the density, and the equations of motion are of the form:

$$\frac{d^2x^a}{ds^2} = g^{a\beta}\left(\frac{\partial\varphi_\beta}{\partial x^\gamma} - \frac{\partial\varphi_\gamma}{\partial x^\beta}\right)\frac{dx^\gamma}{ds} + p\frac{d\varphi_\beta}{ds}\left(g^{a\beta} - \frac{dx^a}{ds}\frac{dx^\beta}{ds}\right)$$

where $g^{a\beta}$ is the contravariant Minkowski tensor and p is a constant. If $p = 0$, these equations of motion are of Maxwell type and are derivable from the variational principle:

$$\delta \int (ds - \varphi_a dx^a) = 0$$

We have also examined a wide class of vector potential theories with several disposable parameters recently introduced by P. Kustaanheimo[10]. He postulates equations of motion of the form:

$$\frac{d^2x^a}{ds^2} = \frac{\partial\varphi^\eta}{\partial x^\varepsilon}B^{a\varepsilon}_{\beta\gamma\eta}(\varphi^\delta)\frac{dx^\beta}{ds}\frac{dx^\gamma}{ds}$$

where φ^δ satisfies the first equation in this section and $B^a_{\beta\gamma\eta}$ are general tensor functions of φ^δ.

Tensor Theories

Under this heading (which, strictly speaking, includes general relativity) we consider Birkhoff's theory[11], Whitehead's theory[12] and the generalization of the latter due to A. Schild[13].

In Birkhoff's theory the distribution of matter is represented by the energy-momentum tensor:

$$T^{a\beta} = \rho\frac{dx^a}{ds}\frac{dx^\beta}{ds} - \frac{p}{c^2}g^{a\beta}$$

where ρ is the density, p the pressure and $g^{a\beta}$ the Minkowski tensor. The condition $p = \frac{1}{3}\rho c^2$ was imposed by Birkhoff in order that the effects of small disturbances be propagated with velocity c. The gravitational tensor potentials $h^{a\beta}$ are defined as the solutions of:

$$\Box h^{a\beta} = (8\pi G/c^2)T^{a\beta}$$

subject to the boundary conditions that all $h^{a\beta}$ are zero at points infinitely distant from gravitating matter. Birkhoff assumed that the equations of motion of a test-particle are given by:

$$\frac{\partial T^{a\beta}}{\partial x^\beta} = f^a$$

where f^a is the body-force per unit volume. He also postulated that f^a is perpendicular to dx^a/ds, is linear in the first derivatives of the tensor potentials, quadratic in dx^a/ds and proportional to the proper density of the particle. The equations of motion then reduce to the form:

$$\frac{d^2x^a}{ds^2} = g^{a\beta}\left(\frac{\partial h_{\beta\gamma}}{\partial x^\delta} - \frac{\partial h_{\gamma\delta}}{\partial x^\beta}\right)\frac{dx^\gamma}{ds}\frac{dx^\delta}{ds}$$

Whitehead's theory is an action-at-a-distance theory in Minkowski space-time, particles interacting through retarded gravitational potentials. In 1924, Eddington[14] showed that the equations of motion for the one-body problem in Whitehead's theory are formally identical with the corresponding equations in general relativity if the Schwarzschild metric is represented in a suitable co-ordinate system. Later this suggestion led Schild to construct an infinite set of theories of Whitehead's type, that is, action-at-a-distance theories in Minkowski space-time. The metric tensor for the Schwarzschild solution can be written:

$$\sigma_{a\beta} = g_{a\beta} + h_{a\beta}$$

where $g_{a\beta}$ is the Minkowski metric tensor, and:

$$h_{00} = -\frac{2GM}{c^2},\quad h_{0a} = h_{a0} = 0,$$

$$h_{ab} = \frac{-2GM/c^2r}{1-2GM/c^2r}\frac{x^a x^b}{r^2},$$

$r = (x^a x^a)^{1/2}$, and $a,b = 1, 2, 3$. Schild introduces a general transformation $x^0 \to \bar{x}^0$, $x^a \to \bar{x}^a$, of the form :

$$x^0 = \bar{x}^0 - \frac{2GM}{c^3}\,\psi\left(\frac{2GM}{c^2\bar{r}}\right)$$

$$x^a = \bar{x}^a\left\{1 + \varphi\left(\frac{2GM}{c^2\bar{r}}\right)\right\}$$

where $\bar{r} = (\bar{x}^a\bar{x}^a)^{1/2}$. To order $1/c^2$, we write, where b is a constant :

$$\varphi\left(\frac{2GM}{c^2\bar{r}}\right) = b\left(\frac{2GM}{c^2\bar{r}}\right)$$

Whitehead's original theory corresponds to the choice $\varphi = 0$, $\psi(v) = \log\{v/(1 - v)\}$. The paths of test-particles are given by the variational principle :

$$\delta\int d\sigma = 0$$

where

$$d\sigma^2 = \sigma_{\alpha\beta}dx^\alpha dx^\beta$$

and light-paths by the condition $d\sigma = 0$. Further, it is assumed that the period of an atom at rest is given by equal intervals σ.

In addition to the above theories, we have also examined a different type of Lorentz-invariant theory due to Poincaré.

Poincaré's Theory

In this theory[15] the inverse-square law of gravitation was re-expressed in Lorentz-invariant form. The equations of motion for a particle of mass m_1 at position x_1^a at time t_1 in the field of a particle of mass m_2 at position x_2^a at time $t_2 = t_1 - r/c$, where $r^2 = (x_1^a - x^a)\ (x_2^a - x_2^a)$, are of the form :

$$\frac{d^2x_1^a}{ds_1^2} = -\frac{Gm_2}{c^2\rho_2^3}\ \gamma^n\left(x_1^a - x_2^a - \frac{\rho_1}{\gamma}\frac{dx_2^a}{ds_2}\right)$$

where

$$\rho_r = g_{\alpha\beta}\frac{dx^\alpha}{ds_r}\ (x_1^\beta - x_2^\beta)$$

for $r = 1, 2$, $g_{\alpha\beta}$ is the covariant Minkowski tensor,

$$\gamma = g_{\alpha\beta}\frac{dx_1^\alpha}{ds}\frac{dx_2^\alpha}{ds}$$

and n is a constant.

The One-Body Problem

In the following table for the three Einstein tests (obtained in general relativity from the Schwarzschild metric), the units employed are as follows : (1) the advance of perihelion per revolution is expressed in units of $6\pi GM/c^2a(1 - e^2)$ radians, where M is the mass of the central body, a is the semi-major axis and e the eccentricity of the orbital ellipse ; (2) the deflexion of a light-ray is expressed in units of $4GM/c^2R$ radians, where R is the minimum distance of the light-ray from O the centre of mass of the central body ; (3) the gravitational red-shift is expressed by the value assigned to :

$$\frac{\delta\lambda/\lambda}{GM/c^2r}$$

where λ is the wave-length of a standard spectral line emitted by an atom at 'infinity', that is, where the gravitational field of the central body is negligible, and $\lambda + \delta\lambda$ is the wave-length of the corresponding line emitted by an atom at distance r from O.

Table 1

Theory	Advance of perihelion	Deflexion of light	Gravitational red shift
1. General relativity	1	1	1
2. Nordström's (generalized) :			
$q = 0$ (Nordström)	$(q-1)/3$	0	1
$q = 1/2$ (Littlewood, Bergmann)	$-1/3$	0	1
$q = 4$	$-1/6$	0	1
3. Milne's	1	0	1
4. Scalar potential with a variable velocity of light :	$-1/6$	—	—
Theory (i)	2/3	1/2	1
Theory (ii)	1	1/2	1
5. Vector potential : $p = 0$	1/6	0	0
$p > 0$	$(1+2p)/6$	$p\pi GM/8c^2R$	—
6. Kustaanheimo's*	1	1	1
7. Birkhoff's	1	1	1
8. Whitehead's (generalized)	1	1	1
9. Poincaré's : $n \leqslant 2$	$n/6$	0	0
$n > 2$	$n/6$	—	—
$n = 2$	1/3	1/2	1

*This theory contains a large number of arbitrary parameters. Conditions have been imposed on them *ad hoc* so that the theory predicts the same results as general relativity for all three effects.

The Two-Body Problem

Although it has not proved possible to formulate a complete solution of the two-body problem in general relativity, approximate solutions can be obtained. Levi-Cività[15] reached the conclusion that, to order $1/c^2$, the centre of mass of two unequal bodies would be automatically accelerated along the major axis of the relative orbit, in the direction of the periastron of the larger mass. Since the periastron always slowly revolves, Levi-Cività's result would imply that a binary star considered as a whole would describe a circle. However, when the problem was re-examined by Eddington and Clark[16], working to the same order of approximation, they found that an error had been made by de Sitter in calculating a general formula, used by Levi-Cività, for the line-element due to n bodies. The effect of the resulting correction was to make the secular acceleration of the centre of mass of the two-body system zero, at least to order $1/c^2$.

In 1954, Clark[17] considered the two-body problem in Whitehead's original theory and found that the centre of mass would have a secular acceleration towards the periastron of the more massive component. In his paper in 1955, Schild conjectured that "all theories of Whitehead's type violate the law of action and reaction, and that they all predict a secular acceleration of the centre of mass in the two-body problem". We have found that, although this is true in general, for certain functions φ (all those for which $b = 1/4$) there is, to order $1/c^2$, no secular acceleration of the centre of mass.

In Table 2 are listed the results which we have obtained for the respective theories, correct to order $1/c^2$ for the following :

(1) the acceleration of the centre of mass of a binary system towards the periastron of the orbit of the more massive component expressed as an increase of velocity in this direction per revolution in units of :

$$\frac{\pi G^{3/2}m_1m_2(m_1 - m_2)e}{\{ma(1 - e^2)\}^{3/2}c^2}$$

cm. per sec. per revolution, where m_1, m_2 are the respective masses, m is the total mass, and a, e are the semi-major axis and eccentricity, respectively, of the relative orbital ellipse ; (2) the advance of periastron per revolution expressed in units of $6\pi GM/c^2a(1 - e^2)$ radians.

Table 2

Theory	Acceleration of centre of mass	Advance of periastron
1. General relativity	0	$\frac{1}{3}$
2. Nordström's (generalized):	$2q-1$	$\frac{q-1}{3} - \frac{(2q-1)}{3}\frac{m_1m_2}{m^2}$
$q = 0$ (Nordström)	-1	$-\frac{1}{3} + \frac{1}{3}\frac{m_1m_2}{m^2}$
$q = 1/2$ (Littlewood, Bergmann)	0	$-1/6$
4. Scalar potential with a variable velocity of light:		
Theory (i)	3	$\frac{2}{3} - 2\frac{m_1m_2}{m^2}$
Theory (ii)	5	$1 - \frac{8}{3}\frac{m_1m_2}{m^2}$
5. Vector potential	p	$\frac{1+2p}{6} - \frac{p}{3}\frac{m_1m_2}{m^2}$
6. Kustaanheimo's*	0	1
7. Birkhoff's	1	$1 - \frac{2}{3}\frac{m_1m_2}{m^2}$
8. Whitehead's (generalized):	$1-4b$	$1 + \frac{(4b-1)}{3}\frac{m_1m_2}{m^2}$
$b = 0$ (Whitehead)	1	$1 - \frac{1}{3}\frac{m_1m_2}{m^2}$
$b = 1/4$	0	1
9. Poincaré's	0	$\pi/6$

* Conditions have been imposed *ad hoc* on the arbitrary parameters in this theory so that it predicts the same results as general relativity for the effects listed in both Table 1 and Table 2.

Additional Effects in the One-body Problem

Two additional effects arise in the one-body problem when due account is taken of the axial rotation of the central body: there is an additional advance of perihelion, and the normal to the plane of the orbit precesses about the axis of rotation of the central body. Effects of this type were first obtained in general relativity by Lense and Thirring[18], working to order $1/c^2$. We have calculated similar effects in Lorentz-invariant theories to the same order of approximation. Since Poincaré's theory was not originally formulated so as to apply to continuous distributions of gravitating matter, we have extended his theory by the same method as that followed by Rayner[19] in the case of Whitehead's theory in its original form ($b = 0$).

In Table 3 we list for the respective theories:

(1) The *additional* advance of perihelion, expressed in units of:

$$\frac{2\pi}{5}\frac{(GM)^{1/2}}{\{a(1-e^2)\}^{3/2}}\frac{\omega R^2}{c^2}\cos\alpha$$

radians per revolution, where R is the radius of the central body (a sphere of mass M), ω its angular velocity, α the angle between its axis of rotation and the normal to the plane of the orbit of the test-particle (to the order of approximation considered this angle remains constant in all theories), and a, e are the semi-major axis and eccentricity of the orbital ellipse. (The expression can also be written in the concise form:

$$\left(\frac{I\omega\omega'}{Mc^2}\right)\frac{\pi\cos\alpha}{(1-e^2)^{3/2}}$$

where $I = 2MR^2/5$, that is, the moment of inertia of the homogeneous sphere about a diameter, and ω' is the mean angular velocity in the orbital ellipse.)

(2) The rate of precession of the normal to the plane of the orbit about the axis of rotation of the central body, expressed in units of:

$$\frac{\pi}{5}\frac{(GM)^{1/2}}{\{a(1-e^2)\}^{3/2}}\frac{\omega R^2}{c^2}$$

radians per orbital revolution.

In the case of Whitehead's theory, a further advance of perihelion arises due to the fact that the central body is no longer being treated as if it were of zero radius[20]. Thus, even if ω were zero the perihelion advance would not be the same as that given by general relativity, but would be:

$$\frac{6\pi GM}{c^2a(1-e^2)}\left\{1 + \frac{(4+e^2)}{10(1-e^2)^2}\left(\frac{R}{a}\right)^2\right\}$$

For e^2 small, the ratio of this additional term to the term when $R = 0$ is approximately $2R^2/5a^2$. It is therefore appreciable if a is not too large compared with R.

Conclusions

(1) On inspecting Table 1, we note that the gravitational red-shift is the least sensitive of Einstein's tests for general relativity. The same effect is predicted by almost all Lorentz-invariant theories. For, apart from Poincaré's theory with $n < 2$ and the vector potential theory with $p = 0$, the only exceptions are those theories in which it has not been possible to make the calculation. We may therefore conclude that this effect is essentially a special relativity effect arising when the ideas of that theory are applied to the study of gravitational fields.

(2) On the other hand, with the exception of Kustaanheimo's theory (which contains a large number of unspecified parameters), the only theories which agree with general relativity in their predictions for both the advance of perihelion and the deflexion of light in the one-body problem are the tensor theories of Birkhoff and Whitehead-Schild.

(3) If, however, we take into account the finite radius of the central body, then Whitehead's theory yields an additional term for the advance of perihelion in the one-body problem, irrespective of whether the central body is rotating.

(4) In the case of the two-body problem (Table 2), there arise two highly sensitive tests for general relativity. For, with the possible exception of Kustaanheimo's theory, there is complete agreement with general relativity only in one particular instance of the Whitehead-Schild set of theories and in Poincaré's theory with a particular value of n ($n = 6$).

(5) Turning to Table 3, we note that no theory agrees with general relativity in all five tests of the one-body problem, for even in the case of Whitehead's theory there is a discrepancy due to the effect of the non-zero radius of the central body. The discrepancy between Kustaanheimo's theory and

Table 3

Theory	Additional advance of perihelion due to rotation of central body	Rate of orbital precession
1. General relativity	-8	8
2. Nordström's (generalized)	0	0
5. Vector potential	$-(p+2)$	$p+2$
6. Kustaanheimo's*	-6	arbitrary
7. Birkhoff's	-6	6
8. Whitehead's†	-8	8
9. Poincaré's	$-(n+1)$	$n+1$

* Conditions have been imposed *ad hoc* on the arbitrary parameters in this theory so that it predicts the same results as general relativity for the effects listed in both Table 1 and Table 2.

† We have considered here the only original Whitehead theory.

general relativity is particularly striking in view of the large number of arbitrary parameters occurring in the former theory. Whatever particular values are assigned to these parameters to make the predictions of that theory agree with those of general relativity in Tables 1 and 2, it is impossible to make the two theories agree in the first column of Table 3.

(6) We may therefore conclude that no Lorentz-invariant theory of gravitation predicts all the effects considered here in complete agreement with general relativity.

(7) Finally, as regards possible practical application, it is of interest to consider the orders of magnitude of the respective effects for artificial satellites moving in orbits about the Earth with suitably chosen values of a. For an artificial satellite moving around the Earth at a mean height above the surface of the order of 1,000 km., the advance of perigee (uncorrected for the effect of the Earth's rotation) is of the order 10 sec. of arc per year, whereas the rotation correction effect is of the order 0·3 sec. of arc per year in the case of general relativity. The biggest observable discriminating effect would arise, however, in connexion with the additional advance of perigee in Whitehead's theory due to the finite radius of the Earth. For this could amount to about a quarter of the uncorrected advance, whereas it would be zero in the case of general relativity.

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UTILIZATION OF NITRIC OXIDE BY MICRO-ORGANISMS AND HIGHER PLANTS

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ALTHOUGH the metabolism of inorganic nitrogen compounds has been the subject of intensive investigation in recent years, the intermediates have not been unequivocally identified. It is generally considered that nitrate assimilation and nitrification occur in a series of two-electron steps[1–3]. Nitric oxide, which is formed by a one-electron reduction of nitrite, has long been recognized as a product of denitrification[4,5]; but it has not been suggested as an intermediate in the assimilatory reduction of nitrate[3,5]. During the course of work on the dissimilatory reduction of nitrate by *Pseudomonas aeruginosa*[6–8] and the assimilation of nitrate in *Neurospora crassa*[3], we have obtained evidence that nitric oxide may well be a common intermediate, and we have therefore re-examined the position of nitric oxide in various pathways of inorganic nitrogen metabolism.

Denitrification

Several early workers[9–11] reported the production of brown fumes during the fermentation of beet and identified them as nitrogen dioxide formed by the oxidation of nitric oxide. More recently nitric oxide has been found to be a product of denitrification in soil[12,13] and also in silage fermentation[14]. Bacteria known to produce nitric oxide during the dissimilatory reduction of nitrate or nitrite include *Bacillus licheniformis*[15], *Thiobacillus denitrificans*[16], *Pseudomonas aeruginosa*[8] and *Micrococcus denitrificans*[17]. There have also been several reports of the production of nitrogen gas from nitric oxide by bacteria[16–19]. Chung and Najjar[18] partially characterized a nitric oxide reductase from *P. stutzeri* and concluded that it was a flavoprotein requiring both iron and copper for its activity. The dialysis techniques used by these workers to establish the metal requirements are open to question since iron, copper and, to a smaller extent, zinc reactivated the enzyme after it had been subjected to prolonged dialysis against salicylaldoxime. The metal effects could therefore have resulted from the removal of residual chelate bound to the enzyme since the reversal of the inhibition was in the order of the affinities of the metals for salicylaldoxime.

Nitric oxide reductase purified 25-fold from *P. aeruginosa*, as shown in Table 1, is a metallo-flavoprotein[7]. The activity of the purified enzyme, which utilized reduced pyocyanine but not reduced pyridine nucleotides as the hydrogen donor, was maximal at *p*H 8·0. Sulphydryl groups appear to be required for the enzyme activity since glutathione partially offset the inhibition of *p*-chloromercuribenzoate, as shown in Table 2. A flavin requirement for the enzyme was indicated by the reversal of mepacrine inhibition with flavin mononucleotide (FMN) or flavinadenine dinucleotide (FAD) and confirmed by precipitating the enzyme three times with ammonium sulphate (*p*H 7·0), when its activity, diminished by about 70 per cent, was reconstituted by FMN or FAD (Michaelis–Menten constant, $Km = 4 \times 10^{-5}$ M). At a concentration of 2×10^{-3} M the iron and copper chelating agents, α,α′-dipyridyl, *o*-phenanthroline, potassium ethyl xanthate and 2 : 9 dimethyl 1 : 10 phenanthroline, inhibited the enzyme by more than 40 per cent. Salicylaldoxime, α-benzoin oxime and sodium diethyldithiocarbamate, however, which chelate copper but not iron between *p*H 7 and 8 (ref. 20), reduced the enzyme activity by less than 10 per cent. There is some evidence for the concentration of iron, but not

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Table 1. PURIFICATION OF NITRIC OXIDE REDUCTASE FROM *Pseudomonas aeruginosa*

Fraction	Procedure	Volume (ml.)	Total protein (mgm.)	Protein (mgm./ml.)	Total units (μl. NO/hr.)	Specific activity (μl. NO/mgm. protein/hr.)	Recovery (per cent)	Purification
1	Supernatant solution after centrifuging at 18,000 *g*	17·5	301	17·2	1,350	4·5	—	—
2	Precipitate from 0–43 per cent ammonium sulphate saturation of Fraction 1, centrifuged at 5,000 *g* for 5 min. dissolved in 0·005 *M* phosphate buffer (*p*H 8·0)	17·5	155	8·86	1,260	8·1	93	1·8
3	Fraction 2 was added to a diethylaminoethyl cellulose column. The column was eluted with 20 ml. aliquots of 0·01 *M* phosphate buffer (*p*H 8·0). Activity of the fourth aliquot	22·0	8·6	0·39	960	113·5	71	25

Actively denitrifying cells of *P. aeruginosa* (NCIB 8704) were grown in a nitrate–peptone medium (ref. 27) under anaerobic conditions for 24 hr. at 37° C. The harvested cells were washed and stored at − 15° C. 5 gm. frozen cells were suspended in 5 ml. 0·1 *M* phosphate buffer (*p*H 8·0) and disrupted with an ultrasonic probe (20 kc./sec.) for 15 min. at 4° C. The homogenate was diluted to 20 ml. with the same buffer and centrifuged at 18,000 *g* for 45 min. The supernatant solution was used as the source of the crude enzyme. The enzyme activity was assayed using the following Warburg reaction mixture. Main vessel, 1·0 ml. enzyme, 1·1 ml. 0·1 *M* phosphate buffer (*p*H 8·0), 0·1 ml. 10^{-3} *M* pyocyanine; side-arm, 0·1 mgm. crystalline alcohol dehydrogenase, 0·1 ml. 2 per cent v/v ethyl alcohol, 0·1 ml. (300 mμ*M*) reduced diphosphopyridine nucleotide; centre well, 0·2 ml. 20 per cent w/v potassium hydroxide. Gas phase, 25 per cent NO/75 per cent nitrogen. Temp. 30° C. Boiled enzyme controls were included. Protein contents were determined by the Folin method (ref. 28).

copper, in partially purified preparations of the enzyme. Extracts of cells deficient in iron contained decreased nitric oxide reductase activity (25 per cent of normal cells) whereas those of cells deficient in copper, molybdenum, zinc or manganese were unaffected. It seems unlikely, therefore, that copper is required for nitric oxide reductase activity in this organism.

Nitrate Assimilation

McNall and Atkinson[21] showed that *Escherichia coli B*, which reduced nitrate but not nitrite, did not reduce nitric oxide. After repeatedly subculturing the organism on a nitrate medium they obtained a strain (*E. coli, Bn*) which could utilize nitrate or nitric oxide as the sole nitrogen source for growth. Similarly Steinberg[22] succeeded in growing *Aspergillus niger* and *Nicotiana tabacum* on nitrohydroxylaminate ($N_2O_3^=$) which is a hydrate of nitric oxide. We have therefore examined a range of bacteria, fungi, algae and higher plants to determine whether nitric oxide reductase activity is a universal enzyme in organisms which assimilate nitrate. The results in Table 3 show that the uptake of nitric oxide by cells and their extracts was limited to organisms grown with nitrate. Micro-organisms grown on ammonium-nitrogen only showed little or no nitric oxide reductase activity. The effect with higher plants was less clear because of the difficulty of growing them in the complete absence of nitrate or nitrite which are almost invariably produced in the culture solut[illegible] by nitrifying organisms. Indeed, the majority of plants showed undiminished nitrate and nitric oxide reductase activities when grown on ammonium-nitrogen under non-sterile conditions. Roots of wheat seedlings, however, grown under strictly aseptic conditions with nitrate, had five times the enzyme activity of those grown with ammonium chloride as the only nitrogen source. The rate of nitric oxide uptake was very similar to that of nitrate reduction in the same homogenates of micro-organisms or higher plants, for example, *Neurospora crassa* grown on a nitrate medium had a nitric oxide reductase activity of 15 μl. NO (650 mμ *M* NO)/mgm. N/hr. and a nitrate reductase activity of 580 mμ *M* NO_3^- reduced/mgm. N/hr.

Although nitrite reductases from *Neurospora* and higher plants have been studied in some detail[3] the

Table 2. EFFECT OF SOME INHIBITORS ON NITRIC OXIDE REDUCTASE ACTIVITY

Compound	Final conc. of inhibitor (*M*)	Inhibition (per cent)
Potassium cyanide	5×10^{-4}	100
Sodium ethylenediamine tetraacetate	2×10^{-3}	33
α,α'-Dipyridyl	2×10^{-3}	59
o-Phenanthroline	2×10^{-3}	73
Potassium ethyl xanthate	2×10^{-3}	40
2 : 9-Dimethyl 1 : 10-phenanthroline	2×10^{-3}	54
α-Benzoin oxime	saturated	0
Salicylaldoxime	2×10^{-3}	10
Sodium diethyldithiocarbamate	2×10^{-3}	0
Mepacrine hydrochloride	5×10^{-3}	60
,, ,, + 0·2 μ*M* FAD	5×10^{-3}	20
p-Chloromercuribenzoate	2×10^{-3}	40
,, + 0·5 μ*M* glutathione	2×10^{-3}	15

The enzyme (Fraction 3, Table 1) was assayed in the presence of the appropriate compound. The reaction mixture was as described in Table 1. A boiled enzyme control was included for each compound.

Table 3. UTILIZATION OF NITRIC OXIDE BY BACTERIA, FUNGI AND GREEN PLANTS

Nitric oxide uptake: μl. NO/mgm. N/hr.

Organism		Nitrogen source during growth	
		NH_4^+	NO_3^-
Bacterium	*Escherichia coli* (B)*	2	16
Fungi	*Aspergillus niger* (M)	6	24
	Neurospora crassa (wild type *Em*, 5297a)	10	29
	Candida utilis	23	31
	Cryptococcus diffluens	2	14
	Hansenula anomola	1	11
	Torulopsis versatalis	0	3
Alga	*Chlorella pyrenoidosa* (211–8c)	7	17
Higher plants	*Cucurbita pepo* (marrow)† leaf laminæ	24	22
	root tissue	8	6
	Fragaria anannassa (strawberry)† leaf laminæ	—	12
	Brassica oleracea (cauliflower)† leaf laminæ	12	14
	Triticum vulgaris (wheat)‡ root tissue	7	34

* Adapted to grow on nitrate as sole nitrogen source.
† Grown under non-sterile conditions.
‡ Grown under strictly aseptic conditions.

Dr. F. W. Beech supplied the yeast cultures and Dr. E. J. Hewitt and Dr. R. A. Webb some of the plant material.

The nitric oxide uptake was measured in homogenates of various organisms with the following Warburg reaction mixture: Main vessel, 1·0 ml. homogenate, 1·2 ml. 0·1 *M* phosphate buffer (*p*H 7·5); side-arm, 0·1 mgm. crystalline alcohol dehydrogenase, 0·1 ml. 2 per cent v/v ethyl alcohol, 0·1 ml (300 mμ*M*) reduced diphosphopyridine nucleotide; centre well, 0·2 ml. 20 per cent w/v potassium hydroxide. Gas phase, 25 per cent NO/75 per cent N_2. Temperature, 30° C. Boiled enzyme controls were always included. Nitrogen contents were determined as described by Nicholas and Fisher (ref. 29).

Table 4. UTILIZATION OF NITRIC OXIDE BY ORGANISMS WHICH FIX ATMOSPHERIC NITROGEN
The reaction mixture as described in Table 3
Nitric oxide uptake : μl. NO/mgm. N/hr.

Organism		Nitrogen source during growth		
		NH_4^+	NO_3^-	N_2
Bacteria	*Azotobacter vinelandii* (O)	3	29	23
	Clostridium pasteurianum (*W-S*)	10	23	44
Blue-green algae	*Anabaena cylindrica* (1403–2)	3	18	12
	Nostoc muscorum (1453–12)	0	10	8
Higher plants (symbiotic nitrogen fixers)	*Vicia faba* (broad bean) root tissue	—	—	6
	nodular tissue	—	—	20
	Casuarina equisetifolia root tissue	—	—	2
	nodular tissue	—	—	7

Dr. H. E. Davenport supplied the *C. equisetifolia*.

product of the reduction has not hitherto been identified. Walker, of this laboratory, however, using the nitrite reductase from *Neurospora*, has shown that there is a stoichiometric reduction of nitrite to nitric oxide (unpublished work).

Nitrogen Fixation and Nitrification

During the course of investigations on the utilization of nitric oxide it became evident that nitrogen-fixing organisms possessed an active nitric oxide reductase, as shown in Table 4. Thus the bacteria *Azotobacter vinelandii* and *Clostridium pasteurianum* and the blue-green algae *Anabaena cylindrica* and *Nostoc muscorum* all took up nitric oxide when grown with nitrogen gas or nitrate-nitrogen, but not when grown with ammonium-nitrogen. Similarly the nodular tissue of the legume *Vicia faba* (broad bean) and of the non-legume *Casuarina equisetifolia* utilized the gas more rapidly than did the neighbouring root tissue. Nitric oxide inhibited the hydrogenase activity of *A. vinelandii* and *C. pasteurianum* when methylene blue was the hydrogen acceptor[23], but sodium nitrate, nitrite or hyponitrite, nitrous oxide, hydroxylamine or ammonium sulphate were without effect.

Anderson, of this Station, has shown that cell-free extracts of *Nitrosomonas europeae*, which oxidize hydroxylamine to nitrite aerobically[24], produce nitric oxide under anaerobic conditions (unpublished work).

Conclusions

The results presented in this paper support the view that nitric oxide, or a compound with which it equilibrates, is an intermediate in both assimilatory and dissimilatory nitrate reduction. The significance of the nitric oxide uptake in nitrogen-fixing organisms is less clear, but *Rhizobium*, *Azotobacter* and *Clostridium* also contain nitrate, nitrite and hydroxylamine reductases[17,25,26] and these enzymes could all be induced by nitric oxide should it be formed by an initial oxidative step in the fixation process. Preliminary results indicate that nitric oxide may also be formed during the nitrification of hydroxylamine. Thus nitric oxide may well be a key intermediate in the metabolism of inorganic nitrogen compounds in micro-organisms and in higher plants.

One of us (C. A. F.) gratefully acknowledges the receipt of a postgraduate scholarship from the Ministry of Agriculture, Fisheries and Food. We are also grateful to Messrs. D. J. Fisher, W. J. Redmond and M. A. Wright for assistance with some of the experiments.

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PRESENCE OF CELL WALLS LIKE THOSE OF BACTERIA IN *RICKETTSIAE*

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THERE has been uncertainty about the taxonomic position of *Rickettsiae*, organisms that produce disease in man and parasitize a wide range of animals. All pathogenic *Rickettsiae* are considered to be obligate intracellular parasites, and no unequivocal evidence has been obtained of their multiplication in cell-free media. Under the light microscope *Rickettsiae* appear as small Gram-negative rods in the cytoplasm of infected cells. When examined by the electron microscope in air-dried preparations and in ultra-thin sections the organisms appear to have double limiting membranes[1]. Preparations of membranes of *Rickettsia mooseri* were made by Schaechter *et al.*[2], who reported that they contain amino-acids, glucose, hexosamine, glucuronic acid and galactose. These compounds are present in a wide range of organisms, but all bacteria so far studied—and only bacteria—have as a component of their cell walls mucopeptides

containing muramic acid[3]. In the present work, membranes of *R. burneti* have been shown to have muramic acid, and like the cell walls of bacteria to be digested by lysozyme.

Rickettsia (*Coxiella*) *burneti* was grown in embryonated eggs, inoculated at 6 days and harvested after a further 6 days incubation at 35°. Tests for bacterial contamination were negative. Suspensions of organisms were purified as described elsewhere[4], omitting formalin treatment. The suspensions were incubated with 1 per cent sodium deoxycholate in 0·1 *M tris* (hydroxymethyl) amino-methane buffer, *p*H 7·0, for 4 hr. at 45° with constant agitation. Cell-wall preparations similar to those described by Schaechter *et al.* were obtained. These preparations were not morphologically changed by digestion at 37° for 2 hr. with crystalline trypsin (Armour) at a concentration of 100 μgm. per ml. in 0·1 *M tris* buffer, *p*H 7·6. However, digestion for 2 hr. with crystalline egg-white lysozyme, 50 μgm. per ml. in 0·1 *M tris* buffer, *p*H 8·0, containing 0·01 *M* sodium ethylenediamine tetraacetate, resulted in the disappearance of morphologically recognizable cell walls. These are the conditions under which lysozyme digests the walls of Gram-negative bacteria[5]. No precipitation was visible and digestion with heated enzyme did not change the appearance of the cell walls, from which it seems unlikely that aggregation in the presence of the highly basic protein, lysozyme, was responsible for their disappearance. Lysozyme was also shown to liberate material giving a reaction for *N*-acetyl amino-sugars from suspensions of *R. burneti*, just as it does from the cell walls of many species of bacteria[6]. Suspensions of *R. burneti* were treated with egg-white lysozyme under the conditions described above for 3 hr. at 37°. The material was brought to *p*H 9·0 and shown to contain material giving the Morgan–Elson reaction for N-acetyl amino-sugars[7].

Analyses of suspensions of *R. burneti* have also established that they contain muramic acid. The organisms were precipitated with 5 per cent w/v trichloracetic acid. The precipitates were hydrolysed in sealed ampoules with 4 *N* hydrochloric acid at 105° for 4 hr. After removal of excess hydrochloric acid *in vacuo*, hexosamines in the hydrolysates were first concentrated by chromatography on a column of 'Dowex 50' (H^+). The hexosamine peak was transferred to a charcoal–'Celite' column, and glucosamine was eluted with water[8]. The 10 per cent ethanolic eluate, subjected to paper chromatography in butanol–pyridine–water (6 : 4 : 3), showed a spot in the position expected of muramic acid. Material eluted from this spot when submitted to the Elson–Morgan test[9] gave an absorption curve with a maximum at 510 mμ (505 mμ overnight), identical with that of authentic muramic acid isolated from the cell walls of *Staphylococcus aureus* and unlike that of glucosamine (Fig. 1). Such a curve is typical of hexosamines substituted at position 3 (ref. 10), and muramic acid is the only naturally occurring material of this type likely to have withstood the conditions of hydrolysis used. Furthermore, both the acetylated derivative and the substituted pentose obtained on treatment with ninhydrin under appropriate conditions[11] showed identical mobilities on paper chromatography with those of authentic muramic acid derivatives.

Preliminary tests have shown that muramic acid is present in *R. typhi* grown under the same conditions as *R. burneti* and in the mouse pneumonitis

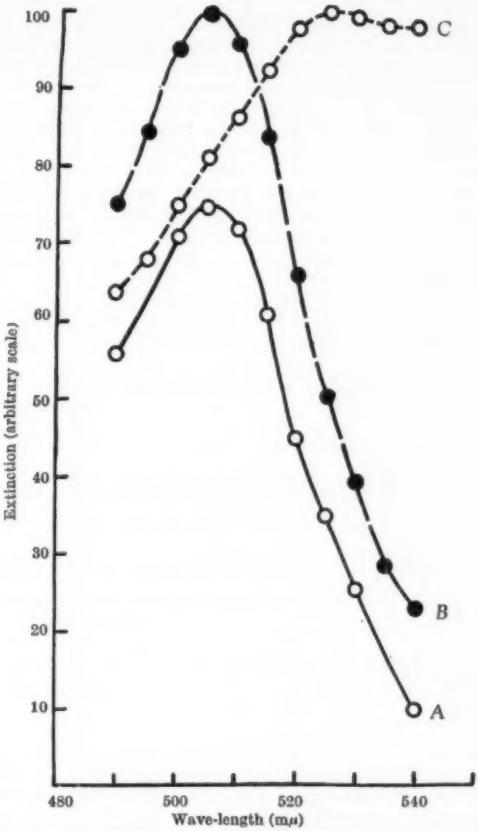

Fig. 1. Absorption curves in Rondle and Morgan tests of: *A*, authentic muramic acid from *Staphylococcus aureus*; *B*, material from *Rickettsia burneti*; *C*, glucosamine

organism (Nigg) grown in mouse embryo cell cultures; the latter belong to the psittacosis-lymphogranuloma group. No trace of muramic acid was detectable in control preparations from uninfected yolk sacs, or in highly concentrated suspensions of vaccinia virus grown in chorioallantoic membranes or influenza virus grown in the allantois of embryonated eggs.

The present work has shown that *Rickettsiae* have cell walls similar to those of bacteria. Since penicillin inhibits bacterial cell wall synthesis[12], the sensitivity of the *Rickettsia* and psittacosis-lymphogranuloma groups of organisms to penicillin may be attributable to their possession of cell walls of this type. In a number of other respects these organisms resemble bacteria rather than true viruses: (1) they have both deoxyribonucleic acid and ribonucleic acid[3,13], whereas true viruses have one or the other (Allison, A. C., and Burke, D. C., unpublished observations); (2) they multiply by binary fission[14], which is not the case in the true viruses; (3) they are sensitive to chloramphenicol and tetracyclines, and purified suspensions of organisms have some capacity for incorporation of amino-acids into protein, which is abolished by chloramphenicol[15].

All these findings suggest that *Rickettsiae* are probably bacteria that have become adapted to intracellular multiplication. Perhaps they have lost the capacity to synthesize certain enzymes necessary for growth and replication, and so have become

obligate intracellular parasites. The apparent inability of suspensions of *Rickettsiae* to utilize glucose, even though they can metabolize tricarboxylic acid cycle intermediates[16], may be a case in point. There is a substantial body of opinion that *Rickettsiae* were originally insect parasites, and among the *Rickettsiae* of insects there seems to be no sharp line of distinction between intracellular and free-living forms[17].

We are indebted to Drs. P. Bradstreet, E. B. Jackson, J. Marshall and to Lederle Laboratories, Inc., for providing suspensions of some of the organisms studied, and for electron micrographs of preparations.

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IDENTIFICATION OF THE RECOMBINANT PRODUCTS OF CANINE AND HUMAN HÆMOGLOBINS

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WHEN a mixture of canine carbonmonoxyhæmoglobin and human carbonmonoxyhæmoglobin A is dissociated at either *p*H 4·7 (ref. 1) or *p*H 11·0 (ref. 2) for 20 min. or more and then recombined at neutral *p*H, two additional electrophoretic components are produced. In slightly acidic buffer, in which all the components are cationic, canine hæmoglobin migrates more slowly than hæmoglobin A; one of the new components migrates more slowly than canine hæmoglobin; and the other migrates more rapidly than hæmoglobin A (Figs. 1 and 3). The exchange reaction:

$$\alpha_2^{A}\beta_2^{A} + \alpha_2^{can}\beta_2^{can} = \alpha_2^{A}\beta_2^{can} + \alpha_2^{can}\beta_2^{A} \qquad (1)$$

though it accounts for the appearance of two new components, does not specify which of the postulated products corresponds to the new fast or the new slow electrophoretic component. Probable compositions of these components have now been determined by recombination of canine hæmoglobin with human hæmoglobins known to be abnormal in either the α-chain or the β-chain.

All dissociations of the equimolar mixtures of canine–human carbonmonoxyhæmoglobin to be described were done at *p*H 4·7, Γ/2 0·10 (acetate buffer) for 24 hr. except where otherwise noted. Dissociation was followed by dialysis in potassium phosphate buffer of *p*H 6·8, Γ/2 0·02 or *p*H 6·3, Γ/2 0·02 at 5° C. for approximately 18 hr. The control and recombined 1 per cent carbonmonoxyhæmoglobin mixtures were analysed by moving-boundary electrophoresis in the same phosphate buffer used for dialysis for 5 hr. at 0·5° with potential gradients of 9·3 (at *p*H 6·8) and 8·5 (at *p*H 6·3) V./cm.

A recombined mixture of canine and S hæmoglobins showed little change in the electrophoretic pattern other than asymmetry of the faster (S) boundary. Electrophoresis of a recombined mixture of canine and C hæmoglobins showed one new component migrating between canine and C in the approximate position of hæmoglobin A and asymmetry of the fastest (C) boundary. Recombination of a mixture of canine, S, and C hæmoglobins which had been dissociated for

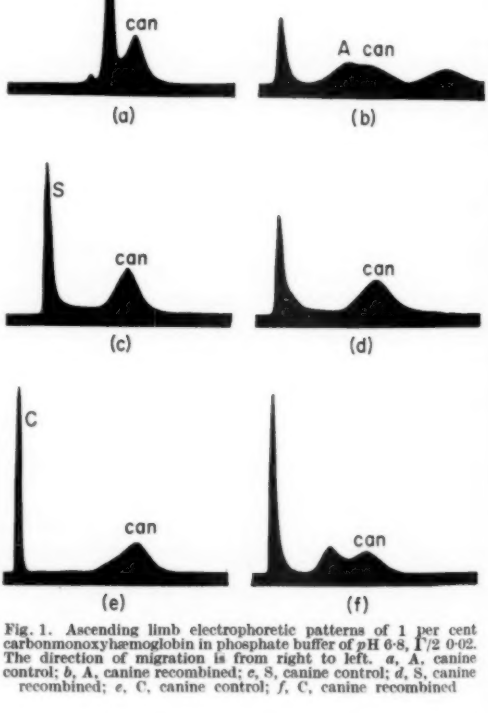

Fig. 1. Ascending limb electrophoretic patterns of 1 per cent carbonmonoxyhæmoglobin in phosphate buffer of *p*H 6·8, Γ/2 0·02. The direction of migration is from right to left. *a*, A, canine control; *b*, A, canine recombined; *c*, S, canine control; *d*, S, canine recombined; *e*, C, canine control; *f*, C, canine recombined

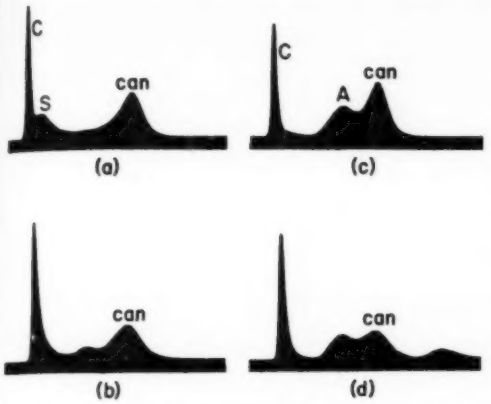

Fig. 2. Ascending limb electrophoretic patterns of 1 per cent carbonmonoxyhæmoglobin in phosphate buffer of *p*H 6·8, Γ/2 0·02. The direction of migration is from right to left. *a*, C, S, canine control; *b*, C, S, canine recombined; *c*, C, A, canine control; *d*, C, A, canine recombined. *b* and *d* were recombined after dissociation for 4 hr.

4 hr. yielded one new component in the approximate position of hæmoglobin A with merging of the original S and C boundaries into one fast unsymmetrical boundary. No component migrating more slowly than canine or more rapidly than C appeared in these experiments. Dissociation (4 hr.) and recombination of a mixture of canine, A, and C hæmoglobins gave one new electrophoretic component migrating more slowly than canine.

At *p*H 6·3, hæmoglobin I migrates more slowly than canine hæmoglobin. Recombination of a dissociated canine–I hæmoglobin mixture (I was isolated from an A–I sample by column chromatography[3]) again yielded only two electrophoretic components, but both boundaries were decidedly skewed and were more widely separated from each other than in the control experiment. Hopkins-2 hæmoglobin (partially purified from Hopkins-2 trait by column chromatography[3]) migrates with canine hæmoglobin as one electrophoretic component at *p*H 6·3. On dissociation and recombination a new component migrating more slowly than canine and Hopkins-2 was observed as well as an increase in the proportion and mobility of the component in the position of hæmoglobin A. A new fast component was also present, but the amount was much less than in the canine-A experiments. The electrophoretic patterns of all experiments are shown in Figs. 1, 2, and 3.

Not one of the results is as clear-cut as the results of I–S[4] and canine–A recombinations, in which each reactant and product was resolved as a separate electrophoretic component. A self-consistent interpretation is nevertheless possible if the observed results and the postulated products of all recombinations are correlated. The exchange reactions of canine hæmoglobin with hæmoglobins S and C, which have altered β-chains[5,6], and with hæmoglobins I[7] and Hopkins-2 (ref. 1), which have altered α-chains, can be represented as follows:

$$\alpha_2^{can}\beta_2^{can} + \alpha_2^{A}\beta_2^{S} = \alpha_2^{can}\beta_2^{S} + \alpha_2^{A}\beta_2^{can} \quad (2)$$

$$\alpha_2^{can}\beta_2^{can} + \alpha_2^{A}\beta_2^{C} = \alpha_2^{can}\beta_2^{C} + \alpha_2^{A}\beta_2^{can} \quad (3)$$

$$\alpha_2^{can}\beta_2^{can} + \alpha_2^{I}\beta_2^{A} = \alpha_2^{can}\beta_2^{A} + \alpha_2^{I}\beta_2^{can} \quad (4)$$

$$\alpha_2^{can}\beta_2^{can} + \alpha_2^{Ho\text{-}2}\beta_2^{A} = \alpha_2^{can}\beta_2^{A} + \alpha_2^{Ho\text{-}2}\beta_2^{can} \quad (5)$$

The new electrophoretic component of lower mobility than canine hæmoglobin in the canine–A recombination did not appear in either the canine–S or the canine–C recombinations. $\alpha_2^{can}\beta_2^{A}$, a product of reaction (1), but not of reactions (2) or (3), must therefore be the new slow component, and $\alpha_2^{A}\beta_2^{can}$, the common product of all three recombinations, must be the new fast component. The mobility of $\alpha_2^{A}\beta_2^{can}$ probably lies between those of S and C since it is not resolved electrophoretically from either. Consideration of reactions (4) and (5) adds support to identification of the new fast component as $\alpha_2^{A}\beta_2^{can}$. This species, which is not postulated as a product in either reaction, was absent in the canine–I recombined mixture and was present in the canine–Ho-2 recombined mixture only in an amount compatible with the proportion of hæmoglobin A known to be present as a contaminant before recombination. A new electrophoretic component appeared in the canine–Ho-2 recombination in the same position and amount as the new slow component of the canine–A recombination, a result consistent with the identification of the new slow component as $\alpha_2^{can}\beta_2^{A}$ since it is a postulated product in both reactions (1) and (5). No new electrophoretic component was resolved in the canine–I recombination; however, the presence of $\alpha_2^{can}\beta_2^{A}$ as postulated by reaction (4) is not excluded because the mobility of this species is similar to that of I.

Identification of the new fast component of the canine–A recombination as $\alpha_2^{A}\beta_2^{can}$ and the new slow component as $\alpha_2^{can}\beta_2^{A}$ permits estimation of the

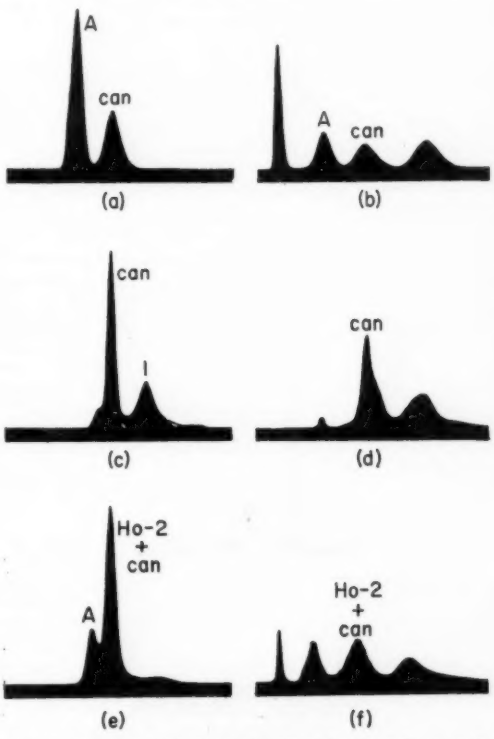

Fig. 3. Ascending limb electrophoretic patterns of 1 per cent carbonmonoxyhæmoglobin in phosphate buffer of *p*H 6·3, Γ/2 0·02. The direction of migration is from right to left. *a*, A, canine control; *b*, A, canine recombined; *c*, canine, I control; *d*, canine, I recombined; *e*, (A), Ho-2, canine control; *f*, (A), Ho-2, canine recombined

Table 1. Composition of Canine and Human Hæmoglobin Mixtures before and after Recombination

Mixture		Electrophoretic Composition (in order of increasing mobility)
can + A	Control	41% $\alpha_2^{can}\beta_2^{can}$; 59% $\alpha_2^{A}\beta_2^{A}$
	Recombined	31% $\alpha_2^{can}\beta_2^{A}$; 24% $\alpha_2^{can}\beta_2^{can}$; 21% $\alpha_2^{A}\beta_2^{A}$; 24% $\alpha_2^{A}\beta_2^{can}$
can + S	Control	50% $\alpha_2^{can}\beta_2^{can}$; 50% $\alpha_2^{A}\beta_2^{S}$
	Recombined	54% $\alpha_2^{can}\beta_2^{S}$ + $\alpha_2^{can}\beta_2^{can}$; 46% $\alpha_2^{A}\beta_2^{S}$ + $\alpha_2^{A}\beta_2^{can}$
can + C	Control	49% $\alpha_2^{can}\beta_2^{can}$ 51% $\alpha_2^{A}\beta_2^{C}$
	Recombined	26% $\alpha_2^{can}\beta_2^{can}$; 22% $\alpha_2^{can}\beta_2^{C}$; 52% $\alpha_2^{A}\beta_2^{C}$ + $\alpha_2^{A}\beta_2^{can}$
can + I	Control	40% $\alpha_2^{I}\beta_2^{A}$; 60% $\alpha_2^{can}\beta_2^{can}$
	Recombined	44% $\alpha_2^{I}\beta_2^{A}$ + $\alpha_2^{can}\beta_2^{A}$; 56% $\alpha_2^{can}\beta_2^{can}$ + $\alpha_2^{I}\beta_2^{can}$
can + Ho-2 (+ A)	Control	80% $\alpha_2^{Ho-2}\beta_2^{A}$ + $\alpha_2^{can}\beta_2^{can}$; 20% $\alpha_2^{A}\beta_2^{A}$
	Recombined	31% $\alpha_2^{can}\beta_2^{A}$; 37% $\alpha_2^{Ho-2}\beta_2^{A}$ + $\alpha_2^{can}\beta_2^{can}$; 23% $\alpha_2^{A}\beta_2$ + $\alpha_2^{Ho-2}\beta_2^{can}$; 9% $\alpha_2^{A}\beta_2^{can}$

mobilities of the other products postulated in reactions (2) to (5) if it assumed that the mobilities of $\alpha_2^{A}\beta_2^{can}$, $\alpha_2^{Ho-2}\beta_2^{can}$ and $\alpha_2^{I}\beta_2^{can}$ are related in the same way as those of hæmoglobins A, Ho-2 and I, and that the mobilities of $\alpha_2^{can}\beta_2^{A}$, $\alpha_2^{can}\beta_2^{S}$ and $\alpha_2^{can}\beta_2^{C}$ are related in the same way as those of hæmoglobins A, S and C. The probable composition of each electrophoretic component in a recombined mixture can then be determined as shown by the following example. No new component was resolved in the S-canine recombination, and one new component with the mobility of hæmoglobin A appeared in the canine–C recombination. The new component of the canine–C recombination must be $\alpha_2^{can}\beta_2^{C}$ since the other postulated product is $\alpha_2^{A}\beta_2^{can}$, which migrates more rapidly than A. Thus the mobility of canine hæmoglobin lies between the mobilities of $\alpha_2^{can}\beta_2^{A}$, the new slow component of the canine–A recombination, and $\alpha_2^{can}\beta_2^{C}$. According to the relative cationic mobilities of hæmoglobins A, S and C (A < S < C) the mobility of $\alpha_2^{can}\beta_2^{S}$ also lies between the mobilities of $\alpha_2^{can}\beta_2^{A}$ and $\alpha_2^{can}\beta_2^{C}$. Consequently the slow component in the recombined S–canine mixture is probably composed of two species of similar mobility, canine hæmoglobin and $\alpha_2^{can}\beta_2^{S}$. The constituent or constituents of the electrophoretic components in all recombined mixtures were determined in this manner and the results summarized in Table 1. It is seen that the observed proportions of the components are consistent with their postulated compositions and with asymmetrical recombination.

Knowledge that the new slow component of the canine–A recombination carries the β-chain of hæmoglobin A, and the new fast component the α-chain, makes possible the use of canine hæmoglobin to identify the aberrant chain of an abnormal human hæmoglobin. Its advantages for this purpose over previously characterized abnormal hæmoglobins such as S and C are that it differs from hæmoglobin A in both chains and is readily available in large quantity. If, for example, a human hæmoglobin is normal in the α-chain (α^{A}) but altered in the β-chain, recombination of this hæmoglobin with canine hæmoglobin should yield the same new fast component of the canine–A experiments ($\alpha_2^{A}\beta_2^{can}$), but the other new component should migrate in a position different from that of $\alpha_2^{can}\beta_2^{A}$. Recombination of fœtal hæmoglobin ($\alpha_2^{A}\gamma_2$)[8–10] and canine hæmoglobin yielded just such a result although the relative mobilities of hæmoglobins A and F are such that $\alpha_2^{can}\beta_2^{A}$ and $\alpha_2^{can}\gamma_2$ migrate in nearly identical positions (Fig. 4). It would be of interest to investigate such hæmoglobins as H (β_4^{A})[11] and 'Bart's' (γ_4)[12] in this manner.

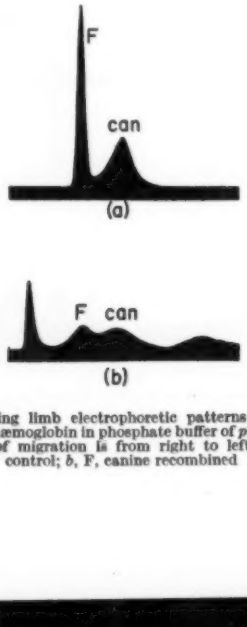

Fig. 4. Ascending limb electrophoretic patterns of 1 per cent carbonmonoxyhæmoglobin in phosphate buffer of pH 6·8, Γ/2 0·02. The direction of migration is from right to left. *a*, F, canine control; *b*, F, canine recombined

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LETTERS TO THE EDITORS

PHYSICS

Gas-Insulation of a Hot Plasma

THE attempts to heat a plasma to thermonuclear temperatures have all started from the idea that the plasma should be separated from the walls of the vessel by magnetic fields in vacuum. The purpose of this communication is to discuss another possibility, namely, to insulate the plasma from the walls by means of a magnetized gas at high pressure. As the thermal conductivity increases with temperature, a hot gas seems to be a poor insulator; but at high temperatures, where the gas becomes ionized, the thermal conductivity can be decreased very much by a magnetic field. Its variation with the temperature is shown qualitatively in Fig. 1. The first maximum is due to the dissociation and the second to ionization, whereas the third is produced by the electron conductivity and the fourth by the ion conductivity. At high temperature the ion conductivity dominates and its asymptotic temperature variation is as $T^{-5/2}$.

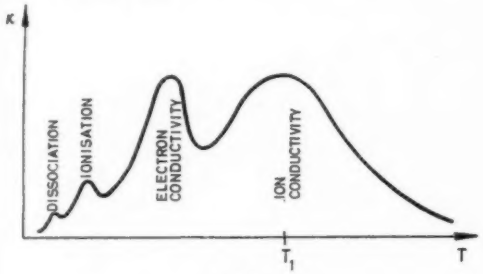

Fig. 1

If in a cylindrical vessel, $r = r_0$, filled with gas, a central region, $r = r_1 < r_0$, is heated with the power Q per unit length but the wall is kept at a low temperature, we have (neglecting radiation losses):

$$Q = -2\pi r\varkappa \frac{dT}{dr} \quad (1)$$

$$Q = \frac{2\pi}{\ln r_0/r_1} \int_0^T \varkappa \, dT \quad (2)$$

Because the integral $\int_0^\infty \varkappa \, dT$ is finite, we can expect a 'burn-out', resulting in a very high central temperature if the power exceeds a certain value Q_b. As the largest part of the integral is due to the ion-gas contribution to $\varkappa$, we can in an approximate calculation use the thermal conductivity of the ion gas only. This is according to Braginskii[1] (see also Rosenbluth[2]).

$$\varkappa = \frac{3}{4\sqrt{\pi}} \frac{k(kT)^{5/2}}{\sqrt{m_i}\, e^4 \lambda} \frac{2{\cdot}645 + 2(\omega_i\tau_i)^2}{0{\cdot}677 + 2{\cdot}70(\omega_i\tau_i)^2 + (\omega_i\tau_i)^4} \quad (3)$$

where $\omega_i\tau_i = \frac{eH}{m_i c} \frac{3\sqrt{m_i}\,(kT)^{3/2}}{4\sqrt{\pi}\,\lambda e^4 n_i}$ (4)

If the pressure $p = nkT = 2n_ikT$ (5

is constant, (3) and (4) give for deuterium:

$$\varkappa = KT^{5/2} \frac{1 + 0{\cdot}756\,(T/T_1)^5}{1 + 3{\cdot}99\,(T/T_1)^5 + 1{\cdot}48\,(T/T_1)^{10}} \quad (6)$$

with $K = 0{\cdot}53 \times 10^{-14}$ W. cm.$^{-1}$ deg.$^{-7/2}$ (7)

$$T_1 = 4{\cdot}0 \times 10^4 \left(\frac{p}{H}\right)^{2/5} \quad (8)$$

T_1 is approximately the temperature that corresponds to maximum ion conductivity.

Introducing the expressions 6–8 into 2, we can write the critical power as:

$$Q_b = \beta K T_1^{7/2} \quad (9)$$

where $\beta = \frac{2\pi}{\ln (r_0/r_1)} \int_0^\infty \frac{x^{5/2}(1 + 0{\cdot}756\,x^5)}{1 + 3{\cdot}99\,x^5 + 1{\cdot}48\,x^{10}} \, dx$ (10)

is a constant of order unity. If the ratio r_0/r_1 is of the order of 10, β is approximately 3. Putting $\beta = 3$, we get:

$$Q_b = 200 \left(\frac{p}{H}\right)^{1{\cdot}4} \text{W. cm.}^{-1} \quad (11)$$

If in a thermonuclear reactor we want $T = 2 \times 10^8$ degrees and $n = 10^{14}$ cm.$^{-3}$, the pressure should be $p = nkT \approx 3 \times 10^6$ dynes/cm.^{2}. Then we find:

$H = 10^4$ gauss	$H = 10^5$ gauss
$T_1 \approx 4 \times 10^8$ degrees	$T_1 \approx 1{\cdot}6 \times 10^8$ degrees
$Q_b \approx 600$ kW. cm.$^{-1}$	$Q_b \approx 24$ kW. cm.$^{-1}$

In a thermonuclear reactor, according to this principle the gas may be heated by a high-pressure arc. Maecker[3] reports for an arc in water vapour at atmospheric pressure that a temperature of 5×10^4 degrees is reached already with a current of 1,400 amp. The temperatures which, according to calculations, are necessary for a 'burn-out', are not very much higher.

In comparison with a vacuum-insulated plasma, the gas-insulated device may have some advantage: (1) it is not subject to the same types of instabilities—but possibly to other types; (2) it should be easy to produce a clean plasma, because the hot region is protected from wall dirt by a thick layer of gas at high pressure.

In order to study the behaviour of a high-density plasma surrounded by neutral gas, an experimental programme has been initiated. To avoid the influence of electrode surfaces an electrodeless discharge is used. In a preliminary experiment a circular discharge has been produced in helium at pressures varying from 1 up to 600 torr in a glass torus of 10 cm. diameter placed between two one-turn coils through which a condenser bank $C = 2\ \mu F.$, 30 kV. is discharged in a damped oscillation with a period of 4 μsec. Kerr cell photographs show that an electrodeless circular arc discharge takes place. The current starts in a very narrow channel, which expands as the current increases. Fig. 2 shows two

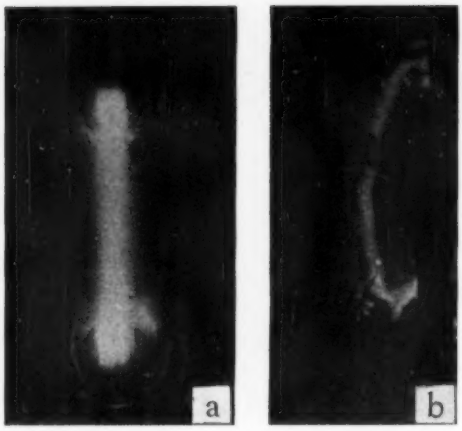

Fig. 2

typical pictures : (*a*) is taken in the symmetry plane of the torus with helium gas at 50 torr pressure when the plasma current has reached its peak value at 25 k.amp. At higher pressure it is necessary to pre-ionize the gas by running a pulsed discharge current of 100 amp. between a number of internal electrodes placed around the torus. Fig. 2*b* shows half of a circular discharge at 400 torr. The picture is taken at an angle to the symmetry plane at the peak value 17 k.amp. of the circulating current. Streak camera pictures indicate that when the gas pressure is high, the plasma looks more regular and stable than at low pressures. Further experiments are in preparation.

We thank Prof. N. Herlofson and Mr. C.-G. Fälthammar for many discussions. Mr. R. Johansson has taken part in the experiments.

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Motion of Molecules in Very Thin Films between Sliding Surfaces

C. L. Gaines[1] has recently discussed the motion which long-chain polar molecules in mono-molecular layers on solid surfaces may undergo. His work leads to considerations of lubrication phenomena which he reports in progress.

Some results which may be related to the study have occurred in sliding studies of optically flat lapped steel surfaces, where the film thickness of stearic acid was that of only several molecular layers.

Information on the structure of the film for room temperatures (well below disorientation temperature) was obtained from observations on the magnitude of the changes in the tangential force at the commencement of, and during, sliding with 'stick-slip' type action. Automatic recording[2] of thirty tangential force-time diagrams for the sliding surfaces was used as in earlier surface sliding work[3], and the results processed to obtain the frequency polygon of all changes in the tangential force, F_T. The magnitudes of the changes in F_T tended to be grouped around multiples of a definite value '*a*', as indicated in the frequency polygon of Fig. 1. This could suggest that sliding can occur at definite strata-levels, and perhaps overturning of the molecules at these levels. Changes in the shearing strength of the film are registered as changes in F_T. In some, but not all, cases, there was micro-interferometric evidence of surface damage and this could not be correlated with the force measurements. It would seem that, although the changes in the shearing strength of any cold-welded metal asperites had contributed to the change in F_T, the final frequency polygon indicates that the changes were mainly due to different shearing strengths of the film at different levels, corresponding to integral multiples of the value at '*a*'.

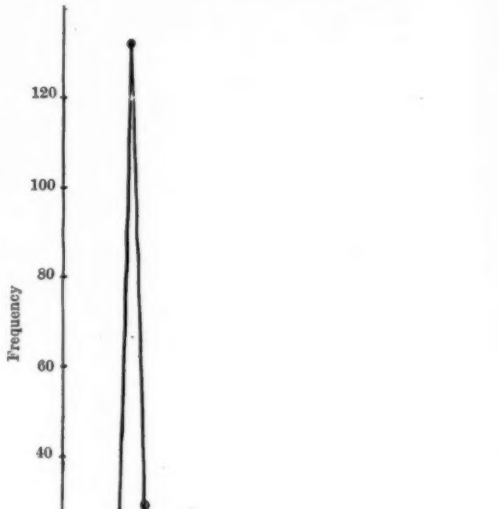

Fig. 1

It would seem that sliding had occurred at selected planes of slip (with overturning ?) which exist by virtue of the molecular surface orientation forces; there would be a low probability of a slip occurring at a molecular plane very close to the metal surface where orientation forces are strongest, but the probability increases for molecular planes further removed from the surface.

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A Silicon γ-Ray Spectrometer

CURRENT pulses produced by the passage of an ionizing particle through a semi-insulator have been reported in the literature[1]. Since most of these materials are, as yet, not available in commercial quantities, we decided to investigate the use of high-resistivity silicon, available as 5,000 ohm cm. *p* type. We estimated that current pulses of about 10^8 ion pairs might be detectable, particularly if the specimen volume is restricted, and the working temperature is lowered to that of liquid air.

Ohmic contacts are made to the specimen by alloying into a boron-diffused surface layer with gold–gallium wire. A number of devices have been prepared most of which detect radiation. The variation of performance between detectors indicates that the processing is not yet under complete control. However, the following performances have been recorded. Gamma-rays from cobalt-60 have produced pulses up to a maximum of 2 mV., for which the signal to noise ratio is greater than 50 at liquid air temperatures, offering the possibility of high-resolution spectroscopy. Other specimens have detected 1-MeV. γ-radiation and 4-MeV. alpha-rays at room temperature, with a signal to noise ratio suitable for monitoring purposes. The current pulses have duration of a few μsec. There is a certain amount of indirect evidence that the thermal cycling programme inherent in the boron diffusion process is modifying the carrier life-time and the compensation of the material[2–4]. This possibility, together with the effect of surface states, is being investigated as essential for production of reproducible devices.

We wish to thank Mr. J. A. Raines for his advice on the diffusion techniques, and Mr. T. James for assistance in fabricating the counters. Permission to publish this communication has been granted by the Admiralty.

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ENGINEERING

Operation of the Backward-Wave Oscillator

WE have recently made some measurements of the voltage distribution along the slow-wave circuit of our 'travelling-wave-tube analogue', operated as a backward-wave oscillator, which are of interest in helping to decide between the various theoretical models which have been proposed to describe backward-wave oscillator operation.

The travelling-wave-tube analogue was described in detail in a recent paper[1], and is based on the lumped circuit travelling-wave tube first described by Matthews[2]. Briefly it consists of a series of drift tubes inside a vacuum envelope interconnected with a series of inductance coils which are outside the vacuum envelope (Fig. 1). The coil-drift tube system simulates an LC delay line the parameters of which can be adjusted to represent those of a normal, practical slow-wave structure. The advantage of the system is that the slow-wave structure properties can be varied, by changing the coils, without breaking the vacuum as would be necessary in the case of a conventional tube. The structure is matched at the opposite end from the gun by means of a high-frequency carbon resistor of appropriate value, while signal is fed on to, or coupled off from, the gun end (according to whether operation is in the forward or backward mode) via a simple T-section network.

Whether the system operates as a forward-wave amplifier, or a backward-wave amplifier or backward-wave oscillator, depends on the electron gun voltage, that is, on choosing the electron velocity so that the electron beam travels in synchronism with the appropriate harmonic. With the particular delay line used, backward-wave operation was obtained for gun voltages ranging between about 200 and 700 volts corresponding to currents of the order of a few milliamperes. No additional attenuation was added to the slow-wave structure—the intrinsic attenuation being sufficient to inhibit operation in spurious modes. The start-oscillation current was found to be about 1·7 mA. and the oscillation frequency about 300 Mc./s., while the coupling impedance of the first backward mode was about 200 ohms, corresponding to an effective *C* value (Pierce's travelling-wave tube gain parameter) of about 0·06 at start-oscillation.

The voltage along the slow-wave structure was measured by means of a coaxial diode probe mounted on a sliding carriage inside the focusing solenoid, enabling it to be connected to each section in turn. Curves of the voltage distribution obtained are shown in Fig. 2. While the mean trend of the points from collector to gun end is exponential, the falling off of voltage in the half-section at the gun end, the minimum occurring in the region of section 3 and the maximum in the neighbourhood of section 7, are all significant and accord very well with the results of the non-linear theory published by Rowe[3]. Comparison of these curves with those of Rowe show a striking similarity, allowing for the fact that our measurements could only be made at discrete points along the structure.

It is quite clear that at least a 3-mode theory is necessary to explain the operation and that a 2-mode theory of the type discussed by Gould[4], although it indicates the right value of starting current, does not predict the correct voltage distribution on the line. It is also important to consider non-linear terms in the

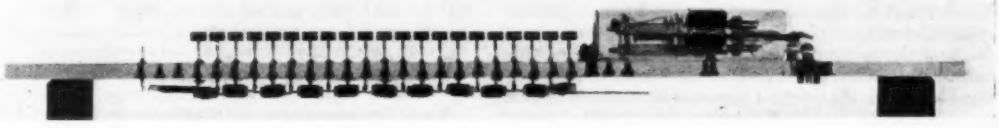

Fig. 1. The lumped circuit backward-wave oscillator analogue

Fig. 2. R.F. voltage distribution on delay line

	D.C. beam voltage (V_0 volts)	D.C. beam current (I_0 m.mA.)
Curve 1	449	3·52
Curve 2	470	3·46
Curve 3	425	3·40
Curve 4	450	2·65

determination of the voltage distribution since the fact that the oscillator becomes stabilized at a finite amplitude at all is a consequence of the non-linearity of the system.

In order to obtain meaningful results great care has to be taken to ensure that the line is correctly matched and that the measuring probe presents an effective open-circuit to the structure. Although the latter condition was realized in these measurements some slight standing wave was present on the line. The amplitude of this was, however, small and does not affect the conclusion drawn above.

Thanks are due to the Admiralty for permission to publish this work.

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GEOPHYSICS

Physical Parameters of the Atmospheric Escape Layer

Nicolet[1] and Urey[2] have made estimates of such physical parameters of the atmospheric escape layer as the height of this critical level, its temperature, and the corresponding scale height, by extrapolation of results of the Rocket Panel[3]. Since the data of the Rocket Panel extend to a height of only 220 km., considerable extrapolation is necessary. Recent results obtained by observation of satellite orbits extend to altitudes sufficiently high to permit direct inference of physical parameters of the atmosphere at the critical level. It is the purpose of this communication to report such results from the data of King-Hele and Walker[4]; the salient feature which emerges is a diurnal variation in the physical parameters associated with the escape layer.

From a result of Spitzer[5], the height ζ of the escape layer above the Earth's surface is fixed by the requirement that:

$$nh = (\pi \sigma^2)^{-1} \quad (1)$$

at this level, where n is the number density of atmospheric particles, h is the scale-height, and σ is the mean collision diameter of an atmospheric particle. The analysis of King-Hele and Walker yields the scale height h directly, but not the number density n. The latter quantity is fixed in terms of the directly inferred density ρ of the atmosphere by:

$$n = (\rho/M)N \quad (2)$$

where N is Avogadro's number and M is the mean molecular weight of the air. In default of measurements by mass spectrometer at these high altitudes, one must estimate M, which introduces a basic uncertainty into the results. In agreement with King-Hele and Walker, M will be taken as 22 at a height of 200 km., decreasing linearly with height to $M = 16$ at 500 km., and constant thereafter. Urey's choice $\sigma = 3{\cdot}15 \times 10^{-8}$ cm. will be taken for the mean collision diameter[2].

Position on line (collector end)

As computed on this basis, the values of nh from the data of King-Hele and Walker are shown as a function of altitude in Fig. 1. Above a height of 300 km., the data points fall on two branches, corresponding to day and night, which actually represent averages for early afternoon and past midnight, respectively. The corresponding heights ζ of the escape layer determined by equation (1) are shown in the second column of Table 1. One notes that ζ is greater for day than for night conditions. This fact is in qualitative accord with my result[6] that the height

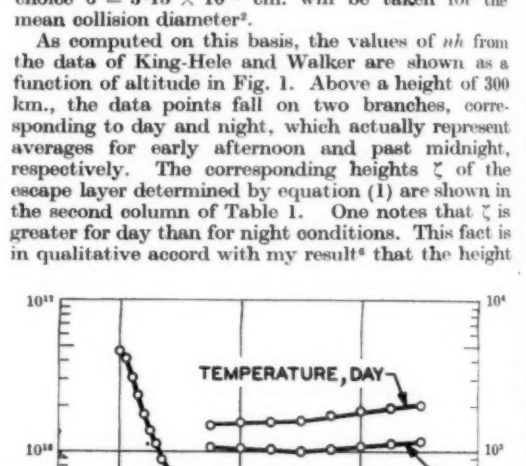

Fig. 1. The parameter nh and the absolute temperature T in the atmosphere as a function of altitude for day and night conditions, from the data of King-Hele and Walker

ζ of the escape layer above the level at which mixing stops is fixed by :

$$\zeta' = H \ln (\pi \sigma^2 Q + 1) \quad (3)$$

where H is the mean scale height in the region below the critical layer and down to the level at which diffusion sets in, and Q is the number of particles in a vertical column of unit cross-section between these two levels. The values of h, ρ, and n appearing in succeeding columns of Table 1 were obtained by interpolation with respect to altitude from the data of King-Hele and Walker. Apart from the effect of the assumptions on M, the standard deviation of the results is perhaps ± 20 per cent.

Table 1. Physical Parameters of the Atmosphere at the Critical Level

Time	ζ (km.)	h (km.)	ρ (gm./c.c.)	n (particle/c.c.)	T (° K.)
Day	670	130	$6{\cdot}6 \times 10^{-16}$	$2{\cdot}5 \times 10^{7}$	2,000
Night	480	61	$1{\cdot}4 \times 10^{-15}$	$5{\cdot}3 \times 10^{7}$	1,000

Since the observations of satellite orbits yield the scale height h directly, the corresponding absolute temperature T follows from :

$$T = Mgh/R \quad (4)$$

where R is the gas constant and g is the gravitational acceleration. Curves of T for day and night conditions are shown as a function of altitude in Fig. 1, as determined under the stated assumptions on M from the data of King-Hele and Walker. These authors quote values for the temperature somewhat higher than correspond to the curves of Fig. 1, since the inverse-square variation of g in equation (4) was taken into account in the present work. The last column of Table 1 shows values of the absolute temperature T at the escape-level for day and night conditions. As a check on the figures, one can note my result[6] that the pressure p at the critical level is simply the mean weight of a molecule distributed over the mean collision area, or :

$$p = (M/N)g\,(\pi \sigma^2)^{-1} \quad (5)$$

which is independent of temperature. On the other hand, p is given also by

$$p = (n/N)RT \quad (6)$$

for an ideal gas. The figures of Table 1 yield approximately the same result for p of equation (6) for the two cases of day and night conditions, and the average value $p = 7{\cdot}1 \times 10^{-12}$ bar is closely that given by equation (5).

In general, the values of ζ in Table 1 exceed estimates made previously ; Urey[2] assumed a range of 300–525 km. depending on the exosphere temperature, while Nicolet[1] obtained 450 km. from a model atmosphere. Both day and night values of the temperature at the critical level are considerably less than the value (of the order of 3,000° K. or higher) inferred by Nicolet[7] and Urey[2] to account for the dissipation of helium-4 from the Earth's atmosphere. Spitzer[5] gives a lower value (1,500° K.), but I have shown[6] that the difference arises from his employment of superseded data in computing the lifetime of helium-4 ; when his computations are corrected by use of Johnson's revision[8] of the data of the Rocket Panel, no significant difference from the results of Nicolet and Urey appears.

The quoted values of the temperature of the escape layer as inferred from the loss of helium-4 presuppose a steady rate of dissipation. The discrepancy (of some 1,000° K. or more) from the values of Table 1 may arise because the dissipation is in fact intermittent, as first suggested by Spitzer. Certainly, the general conclusions obtained from observations of satellite orbits are in harmony with this suggestion, since they imply that solar disturbances (yielding corpuscular radiation, ultra-violet rays, and soft X-rays) largely control the variations of short term in the atmospheric density at moderate heights (200–300 km.)[9–12]. By virtue of equation (3), such variations must be reflected in the height and consequently in the temperature of the escape layer. Accordingly, it is possible that transient solar disturbances of duration too short to be revealed by the satellite observations (lasting for times less than perhaps 10 satellite revolutions) may play a dominant part in the dissipation of helium-4 from the terrestrial atmosphere.

One suspects that more refined data would show a variation with time of day, season of year, and latitude in addition to the gross variation from day to night exhibited by Table 1. Thus, no one set of physical parameters of the escape layer can be universally valid.

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Stress Effects on Thermoremanent Magnetization

It has recently been reported[1,2] that the effect of stress on a rock acquiring a thermoremanent moment is completely reversible. Experiments carried out here have shown this is not true for all rocks. Tests have been made on a number of rocks containing different minerals, and in every case a rotation of moment induced by pressure, together with a reduction of moment, has been observed.

Uniaxial stress experiments were carried out using a non-magnetic pressure vessel designed by one of us (R. N. N.). This consists of a thick-walled hollow dural cylinder with a lid of the same material. Pressure is applied by means of a cylindrical nimonic piston, which compresses a cubical rock specimen against a nimonic cylinder attached to the inside of the lid of the pressure vessel. The rock specimen is heated to its Curie point by means of an a.c. current passing through a nichrome wire element embedded in a fire cement annulus which fits closely around the specimen. The current through this heater is switched off while the specimen is cooling in a magnetizing field of 1·5 œrsted supplied by a Helmholtz coil system.

The apparatus is capable of heating a specimen to 600° C. and cooling it again to room temperature in a period of about 2 hr., while a hydraulic system allows constant pressures between zero and 1,500 kgm./cm.² to be obtained.

Experiments with a particular pressure and field direction were carried out on groups of four specimens. Each specimen was heated four times in all, the sequence being the first and third heatings without pressure, and the second and fourth with pressure. All measurements of inclination and intensity of moment were made using a spinning magnetometer[3] which was modified to be capable of consistently detecting angular differences of 0·3°.

A very detailed study has been carried out on material obtained from a Tertiary dolerite dyke in Skye, Scotland. Initial experiments on material from this dyke showed that the application of uniaxial pressure during the acquisition of a thermoremanent moment caused a rotation of the moment away from the stress axis, together with a reduction in the intensity of the moment. Further experiments were made on the dyke material, which, after one heating, was shown to contain a pure magnetite and an impure maghemite, and the variation of the angular rotation of moment with the following parameters was examined: (i) pressure; (ii) the angle, θ, between the magnetizing field and the pressure axis; (iii) the intensity of the magnetizing field; (iv) the grain size of the magnetic constituents of the rock (composition remaining constant).

All the experiments carried out showed clearly that the application of pressure during magnetization produced a measurable effect. It was found that the observed rotation of moment was dependent on (i), (ii) and (iv), but was apparently independent of the intensity of the magnetizing field in the range 0·5–3·0 oersted. Figs. 1–3 show the results of these investigations.

Further positive experiments have been carried out on rocks containing pyrrhotite, an ilmenite–hæmatite solid solution and a magnetite–ilmenite solid solution. In addition, shear stress has been shown to produce a measurable rotation of moment.

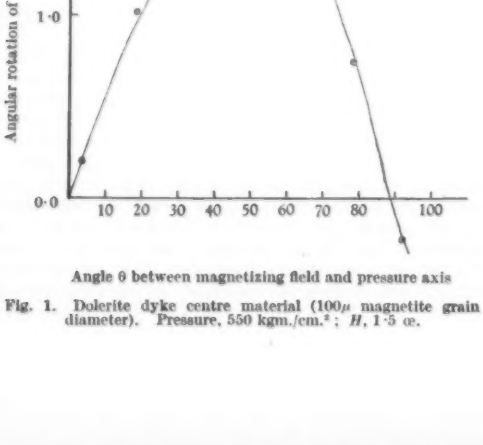

Fig. 1. Dolerite dyke centre material (100μ magnetite grain diameter). Pressure, 550 kgm./cm.²; *H*, 1·5 œ.

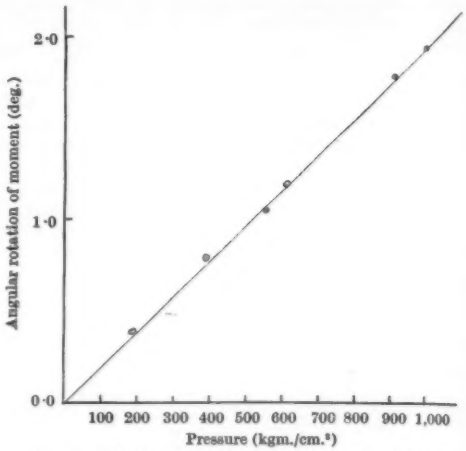

Fig. 2. Dolerite dyke centre material. θ, 45°; *H*, 1·5 œ.

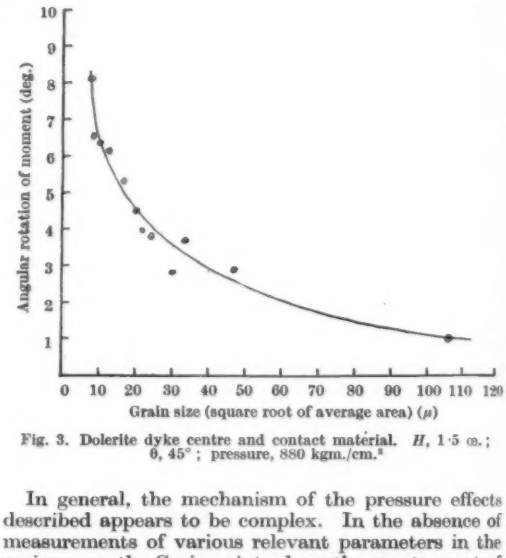

Fig. 3. Dolerite dyke centre and contact material. *H*, 1·5 œ.; θ, 45°; pressure, 880 kgm./cm.²

In general, the mechanism of the pressure effects described appears to be complex. In the absence of measurements of various relevant parameters in the region near the Curie point where the greater part of the moment is acquired, no quantitative relationship between magnetostriction, etc., and the observed pressure effects can be seen. However, the variation of the thermoremanent moment of this dyke material with pressure is not irreconcilable with the known magnetostrictive properties of magnetite reported for room temperatures[4] if it is assumed that magnetostriction decreases regularly to a zero value at the Curie point.

There is a close similarity between the variation of rotation of moment with grain size and the reported variation of coercive force with grain size[5]. It has been suggested that the latter variation results from a change in the mechanism of magnetization, and, if this is so, it is obviously an important factor in the production of angular pressure effects.

It has been found during our experiments that each specimen has a slight intrinsic anisotropy which may cause it to acquire on successive non-pressure heatings

(*Continued on page* 843)

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PROSPECTS OF SCIENTIFIC AND TECHNOLOGICAL ADVANCEMENT

Science and Resources

Prospects and Implications of Technological Advance. Edited by Henry Jarrett. Pp. xiii+250. (Baltimore, Md.: The Johns Hopkins Press; London: Oxford University Press, 1959. Published for Resources for the Future, Inc.) 40*s*. net.

THIS is a most unusual kind of book even although it is a collection of essays. It is the result of a plan by Resources for the Future Incorporated. This is an organization in the United States the job of which it is as a non-profit-making organization to look to the future in the field of research and education so far as it affects the development, conservation and use of natural resources.

The book as a whole provides a look into the future in a number of directions. It originated as a series of lectures which were arranged in a rather original sort of way. First, a leading scientist was invited in his own particular field to give his ideas and views as to future developments and requirements in that field. Naturally, the extent to which the lecturer could look into the future depended very much on the subject under discussion. Secondly, two non-scientific commentators were then invited to discuss and examine the first lecture and to put their points of view forward almost as an informed lay person would do. This gives unusual character to the book and makes it especially profitable in that it can be read by scientists and non-scientists alike. Those familiar with the fields under discussion may no doubt disagree with some of the predictions, for that is inevitable; but the purpose of the book is undoubtedly to stimulate thoughts on problems which affect almost every country. Even although speculation is difficult, there is every reason to engage in it so that even in the immediate future misuse and waste of natural resources may be avoided and that those that are known to exist are utilized to the best possible advantage.

The list of authors of the introductory lectures demonstrates at once that the book is absolutely authoritative: "Genetics", by J. W. Beadle; "Weather Modification", by H. R. Byres; "Exploring for Minerals", by J. A. S. Adams; "Chemical Technology", by E. P. Stevenson; "Nuclear Energy", by W. F. Libby; "New Knowledge from Outer Space", by L. A. DuBridge.

The commentators of these essays come from a wide range of professional disciplines and even from politics. This gives a very stimulating series of additional articles often with a very clearly defined personal point of view but none the less interesting in spite of that. It is clear that the editor has not wielded his pen too strongly and has allowed the authors to give free rein to their thoughts and opinions. This may make the treatment of the topics in the book somewhat uneven; but this is not a text-book or a monograph but eighteen essays devoted to the problems of the future in the fields covered.

H. W. MELVILLE

MAN AND HIS ANCESTORS

Mankind in the Making

The Story of Human Evolution. By Dr. William Howells. Pp. 382+8 plates. (Garden City, New York: Doubleday and Company, Inc., 1959.) 4.95 dollars.

An Introduction to Physical Anthropology

By Prof. M. F. Ashley Montagu. Third edition. Pp. xvi+771. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications 1960.) 116*s*.

DR. HOWELLS has set himself the task of giving a full and detailed account of our knowledge of human evolution, and of telling the story in an informal and light-hearted style. The result is something of a clash between instruction and entertainment. The theme is interlarded with whimsicalities and with technicalities smoothed over by a jocular familiarity ("Man, the hero of the tale" . . . "Proconsul . . . bless his heart!" "Miss Middle Pleistocene" and "Fräulein Steinheim") all done with the best pedagogic intentions. That this exercise in popular writing may not be to everyone's taste should not be allowed to detract from the soundness and competence of Howells's interpretation. The evidence is well marshalled, controversies of the past and present are fairly presented and his judgments appear consistently reasonable. This is particularly evident in his treatment of the rather complex problem of the specific and subspecific relations within the genus *Homo*, involving the allocation of fossil specimens of a diversity ranging from the late but 'fully' Neanderthaloid to the early but more *sapiens*-like varieties, notably Swanscombe man. His handling of the still-vexed problem of *Oreopithecus* (which he regards as a primitive hominoid possibly near the hominid stem) is judicious. So also is his analysis of the status of *Australopithecus* and of *Atlanthropus*. The latter he sees as related to Pekin and Java man, but unworthy of a generic status. The evolutionary chapters are preceded by informative sketches of the living primates and of their vertebrate and mammalian background. Dr. Howells concludes with a description of present-day races which is rather disappointing. There is no serious attempt to utilize the great body of available genetic data in an analysis of the dynamics of human

polytypy as evidenced in the operation of, for example, isolation, mixing and selection as factors responsible for the observed distribution of anthropological characters.

Prof. Ashley Montagu's text-book, in its enlarged and revised third edition, represents a serious endeavour to put the student in touch with many of those issues which Dr. Howells allows to slip by.

Thus after the first chapters (in which a sufficient abundance of the taxonomic and morphological facts of primatology and palæoanthropology are provided) there is an interesting dissertation on the possible evolutionary processes underlying the genesis of the Hominidae and modern man, and particularly on 'neoteny' as a major factor. There follows a chapter of conventional classification and categorization of human racial stocks—an exercise which Montagu, justifiably, finds too limited and arbitrary. He places much more emphasis on the evidence of blood groups and other genetically understood characters as indicators of group affinities.

This section is well documented (though many of the text figure references are not to be found in the bibliography). Population (or as he prefers 'ethnic') differentiation is next considered in relation to mutation, isolation and selective agencies of various kinds —climatic, social, sexual and disease. The interaction of heredity and environment, the usefulness and limitation of the twin method, the determinants of 'constitutional' variation, and a chapter on body composition (by Prof. Brožek) all make up useful sections. An appendix contains an over-compressed guide to techniques of use in physical anthropology.

The book has its merits, but the material is presented in a disconcertingly uneven fashion. In some sections very detailed tables are given with only the slightest relevance to the text, yet the long arguments on 'race' and 'ethnic' differentiation consist in large part of generalities scarcely reinforced by specific evidence. The student could be better served by detailed and quantitative illustration and analysis of, for example, balanced polymorphism, gene-flow between hybridizing populations, mutation-rates or genetic drift. Even the calculation of gene frequencies is dealt with in a somewhat perfunctory way.

There are a number of obvious lapses which careful revision of the manuscript should have put right. For example, in Fig. 44, *Australopithecus* is shown as the crown of the Pongid family whereas in the text (for example, p. 288) its hominid status and particularly that of *Zinjanthropus* is repeatedly conceded. In the same figure the semi-mythical *Africanthropus* is included while Rhodesian man is omitted. There is confusion between orthogenetic and ortholinear evolution (p. 157). The 'early' Kafuan stone industry has for some time been regarded as inadmissible. In matters of dating, the Pleistocene stages are not clearly defined and the Villafranchian, so important for the beginnings of the hominids, is left unexplained. The measurement of human skin colour by reflectance spectrophotometry, the only objective and reliable method, receives no mention in the section on methods.

Despite its blemishes and unevenness, Montagu's is a serviceable text-book; it has the paramount virtue of displaying clearly the full scope of physical anthropology and of conveying in a stimulating way the live issues of the subject.

J. S. Weiner

THE CENTRAL NERVOUS SYSTEM

Evolution of Nervous Control from Primitive Organisms to Man

A Symposium organized by the Section on Medical Sciences of the American Association for the Advancement of Science, and presented at the New York Meeting on December 29–30, 1956. Edited by Allan D. Bass. Pp. vii + 231. (Washington, D.C.: American Association for the Advancement of Science; London: Bailey Bros. and Swinfen, Ltd., 1959.) 52s.

THE title of this symposium is somewhat misleading though this need in no way detract from the value of an excellent collection of monographs contained in the book. The papers here presented do indeed represent, as Mr. Brodie claims, a variety of points of view, written as they are by a botanist, an embryologist, a neurologist, a physiologist, a psychologist and a psychiatrist; but, with the exception of a sketchy contribution by E. W. Sinott on "A Common Basis for Development and Behaviour in Organisms", they contain practically nothing that deals specifically with any theory of evolutionary development of nervous control. They provide, on the other hand, in the main an excellent phenomenological study of the physiological activity of the central nervous system, and there is no evidence that the various contributors envisaged any other purpose.

A highly suggestive note is struck by M. C. Niu in his chapter on chemical inducers. It must be regretfully noted, however, that so far as the nervous system is concerned there is as yet not a single observation that can be said to point to the occurrence of any such inductive process, whether attributable to ribonucleic acid or other body in either the production of mutations or the control of normal development.

The essay by Niu has undoubtedly enhanced the value of the book by reminding neurophysiologists of the important part that may possibly be played by chemical induction, but as yet it remains a possibility only. It is a possibility that can only be fruitful if specificity of inductor elements somewhat in the form of Iscovesco's specific organ inductors should, after all, prove to be a reality. C. I. Prosser suggests that the primitive electrical response of excitable tissue may be of the local graded sort rather than all or none propagated impulses. Together with some analogous speculations contained in the same essay it must very reluctantly be admitted that methods and apparatus for their verification are not yet in sight. H. Grundfest in his contribution entitled "The Evolution of Conduction" gives an excellent critical review of our knowledge of bioelectrogenesis in the nervous system. Defining an excitable cell as one capable of responding to a stimulus by electrogenesis, he distinguishes as distinct functions: the grading in proportion to the strength of the stimulus, and maintained so long as the stimulus lasts, which can be of two types, depolarizing and hyperpolarizing, each of which is produced by a specific transducer action of the electrogenic membrane; and a second generalized function due to the electrically excitable spike generating cell mechanism which can be activated by depolarizing electrical activity of the input and is adapted to conducting a coded message. Grundfest acknowledges that we have as yet no knowledge as to the means by which conducted messages are capable of

releasing specific excitants for the input of the next postjunction cell.

The essay by G. S. Koelle on neurohumeral agents, while giving an excellent account of the present state of our knowledge of the part played by such agents on synaptic transmission, would be enhanced by fuller reference to such facts as are known with reference to the all-important subject of the specific action of local hormones on the central nervous system. J. V. Brady, on the effect of drugs on animal behaviour, has made a gallant attempt to develop an animal laboratory approach to behaviour problems in neuropsychiatry. The urgent need for appreciation of the basic situation of the organism, both as regards the internal and external environment during and preceding any pharmacological experiment, here receives attention which is only too often absent in the evaluation of the neuropharmacological activity of various substances.

The review of brain chemistry by Irvine H. Page is somewhat too ambitious for the twenty pages allotted to it. H. J. Teuber gives his views on alterations of behaviour after brain injury. One could wish that he showed some greater appreciation of the existence of two major difficulties that tend to vitiate the conclusions that psychologists are prone to arrive at in their evaluation of behaviour changes after trauma. First, that anatomical and functional disturbance in the vicinity of the lesion is apt to be of far greater extent that its localization might suggest, and secondly, that the cerebral system is capable of very great lability in its power of compensating lost functions. Further, that without a preliminary knowledge of the pretraumatic mode of function in any given case, such as the habitual type of imagery, assessment of behaviour becomes a matter of utmost difficulty. The essay of I. A. Mirsky on psychoanalysis and human behaviour is obviously out of place in a book of this nature which is not addressed to the clinical psychiatrist.

The volume may be recommended as containing a number of interesting papers, but would certainly benefit greatly if the various contributors had been afforded more space and worked to a more definite scheme of co-operation.

F. GOLLA

ANTIBIOTICS REVIEWED

Antibiotics Annual, 1958–1959

Pp. vii + 1107. (New York: Medical Encyclopedia, Inc.: London: Interscience Publishers, Ltd., 1959.) 90*s*.

Antibiotics Annual, 1959–1960

Pp. xvii + 1034. (New York: Antibiotica, Inc.; London: Interscience Publishers, Ltd., 1960.) 15 dollars. Both volumes edited by Dr. Henry Welch and Dr. Felix Marti-Ibañez.

THE 1958–1959 and 1959–1960 volumes of "Antibiotics Annual" are really an account of the proceedings of the sixth and seventh annual symposia on "Antibiotics", and follow on the whole the pattern established by their predecessors. Both are enormous volumes of more than a thousand pages; both cover almost every conceivable aspect of the antibiotics, and there is a wide variation in standard and in the style of the papers presented.

In the first volume, after opening remarks by Dr. H. Welch and Dr. F. Marti-Ibañez, Sir Howard Florey deals with penicillin in perspective, a paper all the more interesting in view of recent work on synthetic penicillins, some aspects of which are dealt with in the second volume. This article is followed by Dr. S. A. Waksman on the antibiotics of actinomycetes, by Dr. C. S. Keefer on the impact of antibiotics on medicine in the United States, and by Dr. H. F. Dowling on the history of the broad-spectrum antibiotics. The more-detailed papers which follow deal with some long-acting sulphonamides, nitrofurans, phenoxymethyl penicillin (penicillin V), spiramycin, new uses and forms of administration of tetracyclines, oleandomycin and triacetyloleandomycin, tetracycline and oleandomycin combinations, erythromycin propionate, novobiocin, ristocetin (spontin), actinobolin (a new broad-spectrum antibiotic showing some effect against experimental tumours and mouse leukæmias), streptovitacin (another 'anti-tumour' antibiotic), vancomycin, kanamycin and others (this list does not include a number of single articles dealing with isolated topics). The later part of the volume deals mainly with technical methods, such as standardization of antibiotic sensitivity disks and other methods of determining antibiotic sensitivities, epidemiological investigations of the frequency of staphylococci of various types in various communities, and finally some experimental work on the growth-promoting effects of antibiotics in animals.

The volume closes with two panel discussions, first on the current status of erythromycin and kanamycin, novobiocin, oleandomycin, ristocetin and vancomycin, with particular reference to their use in staphylococcal disease, and secondly the causation, prevention and control of staphylococcal disease in hospitals.

In the second volume, again following introductory remarks by Dr. Welch and Dr. Ibañez, there are general articles on the challenge of new drugs to the pharmaceutical industry, to the clinical investigator, to the food and drug administration and to the practising physician. Some of the subjects covered in the special articles are phenoxyethyl penicillin (known as 'Broxil' in the United Kingdom and as 'Syncillin' in the United States), some papers on the effect of various substances on the inhibition of penicillinase in staphylococci, then a series of papers on some new antibiotics with increasingly outlandish names—aspartocin, fervenulin, streptozotocin, rifomycin, paromomycin, and so on. A good many papers are devoted to tetracycline analogues, including the new demethylchlortetracycline. The relative merits of the four tetracyclines are dealt with in one of the few papers from Britain by Prof. L. P. Garrod and Dr. Pamela M. Waterworth, as is the use of injectable tetracycline preparations and the treatment of gonococcal infections by Dr. R. R. Willcox. There are several articles on the incidence of reactions to penicillin and a series of papers on laboratory techniques and methods of testing antibiotic sensitivities. Several papers deal with the anti-fungal antibiotic, griseofulvin, and there is a collection of papers giving clinical and epidemiological investigation of the effects of different antibiotics and antibiotic combinations in a variety of infections.

The second volume ends with two panel discussions, one on the present status and problems involved in human sensitization to antibiotics, and one on the chemotherapy of acute and chronic pædiatric and geriatric infections.

The contents of both volumes are arranged in a rather haphazard way, and it is not always possible

to discern any logical sequence of papers except where a group of papers deals with one antibiotic.

Undoubtedly the most interesting papers in either of these two volumes are those dealing with the new synthetic penicillins. Hints are given of new penicillins to come and it is to be hoped that the next volume will give some interesting information about further developments in this field. R. Knox

BIOCHEMICAL RESPONSE TO INJURY

The Biochemical Response to Injury

Edited by H. B. Stoner, with the assistance of C. J. Threlfall. (A Symposium organized by the Council for International Organizations of Medical Sciences, established under the joint auspices of Unesco and WHO.) Pp. xi+467. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1960.) 57*s.* 6*d.*

THE proceedings of this symposium will be of interest to others besides those concerned practically with the effects of injury and the indefinable syndrome of shock. The book contains seventeen papers which between them consider the effects, measured in a variety of ways, of almost all forms of trauma except irradiation. Each paper gives a comprehensive account of the research of the particular author and of related work by others, so that, with a bibliography of a thousand references with titles and an adequate index, the book is most informative on the tenor and outcome of work over the past decade. Its value is enhanced by a well-edited report of the discussions including a thoughtful account of the strategy, tactics and integration of future work which may be particularly recommended to those who contemplate such work.

Though primarily there may be a specific biochemical lesion, and consequently many inter-related changes at a biochemical level, the response of the animal to injury is a complicated physiological affair in which the nature and extent of biochemical effects is dependent on the constitution of the animal. It is therefore extremely difficult to gauge the significance of any particular biochemical change, and the participants in the symposium were agreed that few general conclusions can yet be drawn. The effect of injury on the vascular system is the core of the problem, but though from time to time a particular substance affecting capillary permeability has been incriminated, it is clear that no single mediator can sustain the role of prime villain in the development of shock. Moreover, the divergence of response to similar injuries in different species complicates the assessment of the general validity of conclusions drawn from certain animal experiments, for example, the importance of the absorption of bacterial endotoxins from the gut in hæmorrhagic shock.

The human response to injury, however, seems to be dominated by an effect on renal function which is rarely apparent in experimental animals, and many of the chapters are of particular interest and importance to clinicians. These include accounts of the disturbance in protein metabolism (Cuthbertson), in water retention and electrolyte loss (Wynn) and in the pituitary–adrenocortical system (Pekkarinen) after surgical trauma or physical injury, the clinical trial of saline therapy (Rosenthal), rouleaux formation (Fåhraeus), and the effect of limb ischæmia on adrenal secretion and body temperature (Stonor and Threlfall).

Other chapters in which the lesions in structure or function produced by specific substances are explored, offer a stimulating challenge to the experimental pathologist, the cytologist and the biochemist; they include the effects of histamine and other endogenous substances (Miles and Wilhelm) and of bacterial toxins (Smith) on vascular permeability, and the early effects of toxic chemicals on mitochondrial structure and function (Fonnesu). The interpretation of these phenomena is still too often handicapped by our ignorance of the physico-chemical nature and interplay of the cell structures involved in the injury, and it is to be hoped that the problems poised in this book will promote further attack in this fundamental field. M. G. Macfarlane

PHYSIOLOGICAL CARCINOLOGY

The Physiology of Crustacea

Edited by Talbot H. Waterman. Vol. 1: Metabolism and Growth. Pp. xvii+670. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 22 dollars.

THIS is the first of two volumes which are intended to give a general survey of our present knowledge of the physiology of Crustacea. There are seventeen chapters, the first of which is an introduction to crustacean biology. This chapter seems to have suffered from over-compression, and contains some curious suggestions regarding the evolutionary relationships of the various crustacean sub-groups. For example, it is suggested that the Ostracoda and Conchostraca have a common origin, without giving any reasons. This is a difficult suggestion for anyone familiar with the two groups to accept, or to understand why it should be made. To offer it, unsupported, to the physiologist looking for an introductory account of the probable evolutionary relationships of crustaceans can only be misleading.

The remaining sixteen chapters deal with a variety of topics, ranging from respiration, circulation and heart function to autotomy and regeneration. These chapters are all written by separate authors, and the book reflects the advantages and disadvantages of such a system. The great advantage is that one gets a variety of outlooks, and each chapter is written by an expert who has contributed original work to the particular field. Most of the chapters not only present useful summaries, but also make suggestions as to where there is need for further work, and where new advances might be expected to be made. The main disadvantage lies in the lack of the rounded overall view that one gets from a single author; but the time has passed when one person could be expected to be equally well informed on the variety of topics covered in this book.

The problems of nomenclature and synonymy have been dealt with very sensibly by providing a systematic index which includes synonyms. This allows the consistent use of one name throughout the text while retaining the possibility of referring back to original accounts which used an older name. As a further aid, particularly to the more advanced worker, each chapter is followed by about a hundred (some by more than two hundred) references, so that apart from

providing a great deal of information this book also provides a detailed guide to the original literature.

Anyone interested in the Crustacea as experimental animals will find this book indispensable, and there is much in it that the ecologist too can benefit from reading.

J. GREEN

DIDACTIC PLANT PHYSIOLOGY

Pflanzenphysiologie

Von Prof. Henrik Lundegårdh. Pp. xv+717. (Jena: Gustav Fischer Verlag, 1960.) 48.70 D.M.

NOBODY having the least acquaintance with Prof. Lundegårdh, either personally or through his published work alone, will expect any book written by him to be tamely conventional. It is perhaps proper therefore to make it clear at the start that, although highly individual, this still sets out to be a general text-book and succeeds. Moreover it attempts, what is admittedly one of the most desirable and yet most difficult achievements in didactic plant physiology, its comprehensive treatment from a single pen. It is characteristic of the author that no concessions whatever have been made to the difficulties he has challenged either by limiting their scope or by shirking them as they arise. On the contrary, the book's limits have been set even wider than might be considered essential; there is, for example, a much fuller treatment of the straight anatomy of the higher plants than is generally considered needful in the context. Less surprisingly, though equally important, the roots of metabolic physiology in chemistry and enzymology receive fully adequate treatment; and the frontiers of physiology with genetics are not forgotten, nor those ecological connexions through which Prof. Lundegårdh himself made his first approaches to physiology.

His unfolding of the subject follows natural lines, proceeding from the organization of the cell and the general properties of protoplasm, through metabolism, nutrition and water balance, to growth and plant movement.

Prof. Lundegårdh has himself made important contributions in many of these fields during the course of his long and distinguished career as a research botanist, and the fact is not hidden from the reader. His adventurous mind has led plant physiologists along more than one exciting trail during the past generation, and this book is sure to make a striking impact on the minds of those students into whose hands it comes. They must surely be stimulated, if they have it in them, to creative thought on their own account. When Prof. Lundegårdh states a case you are left in no doubt about the nature of the problem or his own personal solution of it. You may be stimulated to more or less violent disagreement; but, even if you are of one mind with the author, you are very likely to feel that the matter has been illuminated for you from a new angle. It is probably not possible to write an account of the present state of plant physiology which would satisfy all, or even most, specialists and, if it were, the result would inevitably be much duller than the book Prof. Lundegårdh has written. It appeared first in 1950 in the Swedish language and the version now published in German has been considerably enlarged and partially rewritten. It would be pleasant if it were possible to think that in the next few years an English edition would also be appearing so that it might exercise its influence on the undergraduates of our own botany departments.

W. O. JAMES

BACTERIOLOGY OF THE MOUTH

The Microbial Flora of the Mouth

By Dr. K. A. Bisset and Dr. G. H. G. Davis. Pp. 100+8 plates. (London: Heywood and Co., Ltd., 1960.) 22*s*. 6*d*. net.

THE normal oral cavity supports a very large and varied population of bacteria, fungi and protozoa. These organisms appear shortly after birth, being derived in the first instance from the maternal genital tract and later from the air, clothes, feeding utensils and other environmental objects, and persons, that come into contact with the infant. This microbial flora remains throughout life, undergoing changes that are probably mainly quantitative in the presence of oral infection. Apart from lesions due to specific micro-organisms, such as syphilis or tuberculosis, most infective conditions of the mouth, including the commonest of all, dental caries, are due to, or associated with, the organisms that are normally present. For this and other reasons the role in pathogenesis of the oral flora is not easy to clarify, and much more work on this aspect of oral disease requires to be done. A first essential, of course, is an accurate knowledge of the characteristics of the normal flora and a more or less agreed taxonomy and classification. It is indeed remarkable that such has not yet been achieved, for even the earliest bacteriologists had directed their attention to the organisms of the mouth. No doubt the fact that oral infections are rarely life-destroying has accounted for the lack of sustained interest in this field.

This short book is a very welcome contribution to the study of oral bacterial disease, for it is a succinct account of the oral flora from a systematic point of view, and it gives valuable practical advice. Though it is offered by the authors to dental, medical and bacteriological students as well as to their teachers and to research workers, it is unlikely that it will prove of great interest to undergraduates. Teachers and investigators, however, will find it of considerable value, perhaps not least for the practical information given in the appendixes that follow most of the chapters. There, detailed information on the composition and use of media and on various procedures for isolation is given, with appropriate references to the literature. Information of this sort is not readily available in collected form elsewhere.

R. B. LUCAS

MICROBIAL GENETICS

Microbial Genetics

Tenth Symposium of the Society for General Microbiology held at the Royal Institution, London, April 1960. Edited by W. Hayes and R. C. Clowes. Pp. x+300. (London: Cambridge University Press, 1960. Published for the Society for General Microbiology.) 42*s*. net.

THIS is the first time that a symposium of the Society for General Microbiology has taken the genetics of micro-organisms as its theme. This cautious treading is easy to understand. Microbial

genetics, at present the most rapidly advancing frontier in microbiology, and already crowned by Nobel prizes, practically did not exist before 1940. In twenty years it has leaped by a series of major steps: the techniques for the isolation and use of nutritional mutants in 1940; the identification of deoxyribonucleic acid as the substance responsible for transformation in *Pneumococcus* in 1944; gene recombination in bacteria and in bacterial viruses in 1946; bacteriophage-mediated transduction in 1952; 'parasexuality' in fungi in 1953; unidirectional and partial transfer of genetic material in bacteria in 1953, and many others later.

All these advances have made it clear that micro-organisms present such a variety of processes of genetic recombination that higher organisms seem dull in comparison.

While making possible this spectacular progress in the knowledge of micro-organisms themselves, microbial genetics has opened, and contributed decisively to, the general field of molecular genetics, that is, the description of the processes of heredity and variation at the molecular level. This was the consequence of two main reasons: the enormously increased resolving power of genetic analysis when in one experiment millions, rather than hundreds, of individuals can be handled, and the ease with which chemical techniques can be used with micro-organisms.

This volume, for which the Society and the editors, Drs. Hayes and Clowes, should be congratulated, is the collection of thirteen papers and an introduction presented at the symposium. The standard is very high almost throughout and most of the papers are also presented in an intelligible form. The contributors include some of the best people in the various sections of the subject. It is a volume that no microbiologist can ignore and that all geneticists—especially those without direct acquaintance with microbial genetics—will profit by reading.

G. PONTECORVO

THE FATHER OF MICROSCOPY

Measuring the Invisible World

The Life and Works of Antoni van Leeuwenhoek, F.R.S. By Dr. A. Schierbeek. With a biographical chapter by Dr. Maria Rooseboom. (The Life of Science Library, Vol. 37.) Pp. 223 (28 plates). (London and New York: Abelard-Schuman, Ltd., 1959.) 25*s*. net.

ANTONY VAN LEEUWENHOEK is the most astonishing figure in the history of biology. Unaided, he discovered bacteria, described spermatozoa, and observed a nucleus in a blood-corpuscle. Not for more than 150 years was progress in microscopy resumed at the resolution which Leeuwenhoek could command with his home-made lenses. His discoveries extended over fifty years and were described in a series of some 165 letters to the Royal Society. The last, in 1723, was dictated from his death-bed.

Yet our knowledge of this amazing man has remained strangely incomplete until the present time. Some thirty years ago, a committee of Dutch scientists began the task of assembling a series of volumes in which each of Leeuwenhoek's letters is followed by a modern description of the objects concerned. Since 1942, Dr. A. Schierbeek has been editor-in-chief of this undertaking. In 1950, he published in Dutch a two-volume work on Leeuwenhoek, to which he has now added the present book in the English language. It opens with a valuable biographical chapter by Dr. Maria Rooseboom, who tells us much about the social history of the Netherlands in Leeuwenhoek's day. She makes the point that Leeuwenhoek was first introduced to the Royal Society of London at a time when the two countries were at war.

We are here given a view of the father of microscopy in the round. It would be hard to over-estimate the importance of the service to science which these authors have rendered. Here is a book which all biologists must read, and which every student of the history of the sciences will need to study. One of the most interesting topics which are discussed is Leeuwenhoek's relations with the Royal Society. Though he never met them, these men were his colleagues. Their confirmation in 1677, after repeated trials, of the presence of animalcules in 'pepper water' is a vivid chapter in the history of science. Only fourteen years later, however, Robert Hooke lamented that Leeuwenhoek already stood alone in the use of the microscope. Yet for a further thirty years the Society continued to receive the letters from Delft.

Dr. Schierbeek's book is accompanied by a number of plates reproduced mainly from the original publications of Leeuwenhoek. I would suggest that in further editions the references should be given to the year and page in the *Philosophical Transactions*.

ARTHUR HUGHES

APPLIED MICROBIOLOGY

Advances in Applied Microbiology

Vol. 2. Edited by Wayne W. Umbreit. Pp. xii + 384. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.

ON the whole, the second volume in this series fulfils the promise of the first. The book contains eight fairly comprehensive reviews and eight short articles that were presented during a symposium on "Engineering Advances in Fermentation Practice" before the Division of Agricultural and Food Chemistry at the American Chemical Society meetings in September 1959. Five of the reviews are concerned with the use of micro-organisms in fermentation processes: recent work on the oxidative fermentation of industrial wastes, with particular reference to the disposal of dairy waste, is discussed in a posthumous article by N. Porges; G. J. Haas points out the importance of microbial control during brewing, and details the methods used during the brewing of lager beer; R. J. Allgeier and F. M. Hildebrandt describe the development of the use of deep-fermentation equipment for the manufacture of vinegar; T. H. Soudt contributes an account of the transformations of steroids that can be accomplished with micro-organisms—such interconversions are important adjuncts to chemical synthesis; and W. J. Oswald and C. G. Golueke give an interesting, though at present somewhat hypothetical, discussion of the possibility of biologically transforming solar energy into electrical power. Two reviews deal with the collection and counting of micro-organisms: H. W. Batchelor considers the techniques available for

collecting and measuring particulate matter suspended in air, and R. Ehrlich discusses the properties and applications of membrane filters. In the remaining article, F. Kavanagh contributes a thoughtful essay on the theory, practice and pitfalls of microbiological assays.

As in the first volume, the wide variety of topics covered illustrates the broad scope of the applications of microbiology, but it is perhaps unfortunate that much of the international flavour so desirable in publications of this type has been lost. All the authors are drawn from laboratories in the United States, and several of the chapters, although giving full credit to work done outside the United States, are frankly concerned primarily with American practice in the field discussed.

J. W. G. PORTER

OYSTERS: THEIR BIOLOGY AND GASTRONOMY

The Glorious Oyster

Edited by Hector Bolitho. Pp. 174+17 plates. (London: Sidgwick and Jackson, Ltd., 1960.) 25*s*. net.

Oysters

By Prof. C. M. Yonge. (New Naturalist Special Volume.) Pp. xiv+209+17 plates. (London: William Collins, Sons and Co., Ltd., 1960.) 21*s*. net.

THESE two books provide an interesting contrast. Hector Bolitho is frankly concerned with the pleasures of oyster eating and is supported by W. A. Bentley, in whose restaurant he has no doubt extended his practical experience. Maurice Burton contributes chapters on reproduction and growth, enemies, anatomy and physiology and culture. C. M. Yonge, however, sets out to provide an up-to-date, fully illustrated, scientific account of the structure, biology and cultivation of the European oyster, but includes also references to similar work on other species from the United States, Japan and Australia.

"The Glorious Oyster" first appeared in 1929 but became out of print. This revised and extended edition is well presented and is illustrated by photographs of still-life paintings from collections in Europe and the United States. Some of these, as, for example, that by Jan Steen, which also appears as a frontispiece in Prof. Yonge's book, are well known, but others, such as those by Braque and Manet from private collections, are unfamiliar but very appropriate.

In the section on the history of the oyster, Hector Bolitho has clearly drawn his information mainly from Philpots's monumental work of 1890, and this is acknowledged. The description of oyster dredging at Whitstable, taken from "All the Year Round", of November 26, 1859, is worth every inch of the space it occupies; it will be recognized as authentic by anyone who has worked in the creeks and estuaries of the east coast of Britain. There is an interesting anthology containing not only Sam Weller's "two very remarkable facts" concerning the oyster, but much less-familiar material from Pepys, John Evelyn, Robert Boyle and others.

Maurice Burton's scientific contributions fit easily into the scheme of the book, dwelling rather more on the curious and bizarre features of the oyster's biology than is permissible in a scientific monograph. It is a pity that he repeats the clearly disproved suggestion that the dumping of trinitrotoluene and other explosives was responsible for the catastrophic losses among oysters in Britain in 1920.

Of Prof. Yonge's book it is only necessary to say that, while it upholds the high technical standard of the New Naturalist Special Volumes, it is more readable and of wider interest than some of the earlier books in this series. Clearly his main difficulty has been to compress adequate references to all the major studies on oysters into a monograph of 200 pages. It may be suggested that the description of the extremely scientific oyster culture of Holland should not have been limited to less than a page, but the extraordinary system used in the Norwegian polls has also (necessarily) to be described in a couple of paragraphs. However, all the important references are here for anyone with a desire for further knowledge. The author begins: "This is a small book on a very big subject", and, towards the end, he writes of the consciousness of lack of knowledge about commercially valuable oysters even though they have been more closely studied than any other marine animals. He may rest assured that his latest contribution will help us considerably to appreciate where effort should be applied.

H. A. COLE

LIVESTOCK IN AFRICA

The Indigenous Livestock of Eastern and Southern Africa

By I. L. Mason and J. P. Maule. (Technical Communication No. 14 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh.) Pp. xv+151+179 plates. (Farnham Royal, Bucks: Commonwealth Agricultural Bureaux, 1960.) 45*s*.

AS might be expected, the indigenous livestock of Africa, with few exceptions, have not been improved, even for work purposes, to the extent of those in Asia where ancient civilizations existed. As Norman Wright points out in his foreword, it will probably be easier to increase the production of native breeds adapted to their particular environmental conditions than to import improved breeds unsuited to the local hazards of environment and disease. However, perhaps one might add, except where by suitable crossing and selection the production of the one is combined with the adaptability of the other as in the case of Bonsmara cattle and Dorper sheep.

The book attempts to classify the different types of livestock by various morphological characters—cattle by the position and size of the hump and horns: sheep by their tails, thin, fat or fat rumped; and goats by the length of their ears. Where available, facts are given concerning their size, weight and milk production together with a large number of excellent photographs; references to original descriptions are quoted. For most types estimated numbers and their distribution in different countries are given, but one misses, except in a few cases, an account of the ecological conditions of temperature, altitude, rainfall and type of vegetation with which each type is associated. Nomenclature forms a problem throughout and in the absence of well-recognized

names the authors have adopted the tribal name. With camels, for example, the different tribes often use them for different purposes—pack, riding or milk as well as meat.

As might be expected, the distribution of the different species varies widely; the horse and ass are mainly confined to the north and south of the area, while cattle take their place in the intermediate zone. With cattle too, the zebu type with a large thoracic hump and short horns tends to follow the coastal areas, whereas the sanga type with its small, muscular cervico-thoracic hump and large horns tends to occupy inland areas. One interesting sidelight is that in many breeds individuals either polled or with loose hanging horns exist, showing the wide-spread incidence of this mutation. The genes for all-the-year-round breeding which occur in some types of sheep and goats might well be introduced into Britain. Indigenous breeds of pigs seem to be absent from Africa, for most of the types appear to conform to the breeds of the countries which first colonized the areas and even the small Bantu pig shows evidence of Asiatic origin.

The information given in this book should form a guide as to which of the various types it will be worth while to concentrate on for improvements in production, for Africa is a continent with a great potential for increased food supplies.

John Hammond

PEOPLE AND PARROTS

Verbal Behaviour

By Prof. B. F. Skinner. Pp. x+478. (London: Methuen and Co., Ltd., 1959.) 42*s*. net.

As a psychologist, Prof. Skinner has tackled the basic problem of verbal behaviour: he has not speculated about primeval grunts or the metaphysics of the word and the world, he has simply asked how the individual acquires his verbal skills. This makes such good sense that one wonders why one had not thought of it before: "We are specially reinforced by speakers and writers who say what we are *almost* ready to say ourselves—who take the words 'off the tip of our tongue' . . . The listener may refuse credit and exclaim *Why didn't I think of that* ?, but he must have 'thought of it' to some extent if he accepted it immediately as an effective metaphor or a really apt remark" (p. 272).

The book does not attempt a quantitative or experimental analysis of verbal behaviour: "The emphasis is on an orderly arrangement of well-known facts, in accordance with a formulation of behaviour derived from an experimental analysis of a more rigorous sort" (p. 11). The concepts applied are those of 'operant conditioning', discussed by the same author in his book, "Science and Human Behaviour" (New York, 1954). Given a repertoire of loosely organized instinctual behaviour patterns or responses acquired in other situations, the animal extends its control of the environment by discriminating those of its activities which pay off. The baby gradually converts his babbling to words by progressively accurate discrimination and reproduction of the responses which his parents reward and which he can practise to himself since he both speaks and hears. "At this stage the child resembles a parrot, which is automatically reinforced whenever its vocal productions match something heard in the environment" (p. 164).

Prof. Skinner sets off from this position and gives us a conducted tour of verbal behaviour. This is fascinating: we catch glimpses of magical thinking, psychotherapy, symbols, metaphors, puns, non-Freudian slips, spoonerisms, 'Finnegan's Wake', speech disorders, generalization gradients, universals, linguistic philosophy, stylistic devices, and ways of making people say what we want without actually beating. These are, of course, only glimpses—the value of the book is that it penetrates the clouds in so many places, for example, p. 314, "It is because our behaviour is important to others that it eventually becomes important to us", and p. 7, "We have no more reason to say that a man 'uses the word *water*' in asking for a drink, than to say that he 'uses a reach' in taking the offered glass".

From his analysis the author derives several new concepts—the mand, the tact, the autoclitic—and this is a considerable contribution in addition to the stimulation and insight he gives on the way.

Although one would like to recommend this book to everyone interested in any aspect of language, this might not be fair. This is a psychologist's book, and there is not much exposition of the basic concepts of operant conditioning theory in it. For those who have no acquaintance with the field the book would be harder reading: it would nevertheless be rewarding, and the reader could always refresh himself with forward glances at the later parts from time to time.

P. R. F. Clarke

THE HARVEY LECTURES

The Harvey Lectures

Series 53, 1957–1958. By Dr. John H. Dingle, Dr. Frank Fenner, Dr. H. Fraenkel-Conrat, Dr. Joshua Lederberg, Dr. Arthur Kornberg, Dr. Albert H. Coons, Dr. Daniel Mazia, Dr. J. Gough, Dr. John H. Gibbon, jun. (Delivered under the auspices of the Harvey Society of New York.) Pp. xiv+254. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 7.50 dollars.

The Harvey Society has again amply fulfilled its constitutional aim of "the diffusion of scientific knowledge of the medical sciences". The lectures here published are too different to be adequately summarized, but their interest and variety shows the extent to which medical science now draws on general biology, and, in turn, fertilizes the latter. For example, Dr. F. Fenner's work on myxomatosis is of interest to the anthropologist and student of evolution as well as to the virologist. He points out that few of the viruses we know to-day could survive in scattered populations such as those of Palæolithic man. How then have they arisen? The myxoma virus, from producing a benign tumour disease in the Brazilian rabbit *Sylvilagus*, has become in a short time a virulent general disease of the dense populations of *Oryctolagus*, which have spread from the Mediterranean and especially to Australia. Fenner shows how this spread has been made to provide information about the evolution of viruses, inevitably a difficult study since "viruses exist only to-day, what happened yesterday is already rumour".

Dr. H. Fraenkel-Conrat discusses the tobacco mosaic virus as a "treasure-trove of chemical surprises", especially about the aggregation of protein and nucleic acid *in vitro* to form active virus. He emphasizes the difficulties due to the lack of methods for investigating the fine structure of polynucleotides.

Dr. J. Lederberg provides a fascinating account of sexual processes in bacteria by the movement of a chromosome from one cell to another of a pair. Since this happens progressively the chromosome can be broken at varying stages and the linkage relations studied. "The power and scope of these methods was illustrated . . . by the fact that the simple operation of mixing two mutant cultures on a few selective agar plates can generate information on 10^9 incidents of re-combination—an easy match for the reproductive potentiality of the entire human species".

Other lectures by Dr. D. Mazia on cell division, Dr. A. H. Coons on lymphoid tissue, Dr. A. Kornberg on deoxyribonucleic acid are no less interesting, and the whole volume, though not designed as a unity, provides a striking demonstration of the depth and breadth of medical science.

J. Z. YOUNG

REGENERATION IN ANIMALS

Asexual Propagation and Regeneration

By M. A. Vorontsova and L. D. Liosner. Translated from the Russian by P. M. Allen. Edited by F. Billett. Pp. xxiv+489. (London and New York: Pergamon Press, 1960.) 70*s*. net.

THE study of regeneration in animals has been pursued sporadically since antiquity, was caught and made scientific by Spallanzani, and received the blessing of philosophy from Voltaire. More to the point, its modern history offers us a perfect blend of the marvels of Nature with intellectual challenge, and adds more than a prospect of clinical relevance. Yet few books in English have been devoted to it, and of them only A. E. Needham's most useful, but brief, review is of service in introducing the present-day student to an enormous literature.

The appearance of Marie Vorontsova's book in translation is therefore an important event. It proves to be a happy one in some ways, a disappointing one in others. One cause of disappointment is likely to be all too apparent to the casual reader, and it may be well to mention it at once.

It is rightly felt that complaints about misprints and such-like minor errors argue for intellectual poverty in a reviewer. The price must sometimes be paid, and the making of this book cannot be allowed to pass without protest. The chief offence is in the re-transliteration of the names of Western authors. Dreisch, Abelo, Wolf, Gertwig, Navil', Bronsted and Shul'ts will present little difficulty to regeneration workers. But who is Dzhidzh ? Luckily he worked with Rose and can for that reason be traced as Gidge. There are also some slips of substance in the text, most of which are so obvious as to be more irritating than dangerous.

Of the book itself one can speak with qualified pleasure. The authors begin with a brief survey of the modes of asexual reproduction in animals and their incidence. Spore formation and partheno-genesis are quite reasonably excluded, but the absence of reference to polyembryony is odd. In the few insects and mammals which habitually resort to it, the process is biologically important and full of interest, but it has, of course, little kinship with adult regeneration and is presumably ignored on that account.

The second main section of the book is a treatment of physiological regeneration, that is, of processes of tissue replacement inseparable from normal life. Here the authors are content to discriminate between this and reparative regeneration (that is, replacement following traumatic loss) and to give examples demonstrating the ubiquity of tissue replacement in the animal kingdom.

The last section, constituting more than three-quarters of the whole, is devoted to reparative regeneration, a field in which both authors have themselves done distinguished work.

Here we are given an excellent introductory account of 'true' regeneration in all groups of animals in which it has been demonstrated. The emphasis is, of course, on experimental work designed to reveal the cellular genealogy of regenerates, the causal relations during regenerative morphogenesis, and the factors controlling the incidence of the capacity to regenerate. There are a few important omissions of which nerve regeneration is an example. In partial recompense the large Russian literature is properly represented without depriving non-Russian authors (of works published up to 1955) of their due attention. A final chapter discusses such generalizations as have been proposed to describe regenerative phenomena, or to relate them to asexual reproduction.

The authors are occasionally severe. This is a merit when one happens to agree with them, a blemish when one does not. The concept of regeneration 'fields', for example, is so treated that the reader senses a lack of normal human sympathy for an admittedly inadequate attempt to describe important and puzzling phenomena. They are sceptical about the role of neoblasts in planarian regeneration, and frankly hostile to the claims for a unique role for interstitial cells in hydrozoans. In these, and other matters, their attitude is not so much unreasonable as unduly dogmatic and tinged with a little self-righteousness. Nevertheless, on most of the difficult and long-standing problems of regeneration their views will command agreement or, at very least, respect from the majority of their colleagues. It is certainly of great value to have them so clearly stated.

D. R. NEWTH

NUTRITION AND DIETETICS

World Review of Nutrition and Dietetics

Edited by Prof. Geoffrey H. Bourne. Pp. viii+272+7 plates. (London: Pitman Medical Publishing Co., Ltd., 1959.) 60*s*. net.

THIS volume is the first in an annual series. In the preface the editor refers to the "avalanche" of papers which now envelops students of nutrition and makes it difficult for them to keep in touch with advances in the different branches of the subject. He claims that there is ample scope for a new publication which will provide "more lengthy and discursive reviews than those published in conventional

journals", adding that the reviews will provide critical evaluation and bear the imprint of their authors, whose views and theorizing will be welcomed.

The first number contains ten reviews of a wide variety of subjects, including the effects of androgens and œstrogens on the metabolism of proteins and the growth of tissues, the biosynthesis of vitamin C, basal metabolism in the Japanese population, nutritional factors in anæmia, the use of isotopes in nutrition research, and the nutritional requirements of embryos. The reviews originate in five countries, and the authors are recognized authorities in the fields covered. The volume opens appropriately with a scholarly article on "The History of Nutrition" by E. V. McCollum—almost the last survivor of the founders of modern nutritional science—which contains a good deal of information not generally known. For example, McCollum states that J. B. A. Dumas, the French chemist, was "the first man to suggest that a diet which supplied only protein, fat and carbohydrate was inadequate for the support of life", a conclusion based on experience in the siege of Paris in 1871, when efforts to devise synthetic 'milk substitutes' for infants failed. McCollum records that when he himself was engaged in pioneer research on vitamins in the first decade of the century, he did not know of the fundamental discoveries of Eijkman and Grijns in Java on rice and beriberi, made during the years 1896–1901, because these "were all published in journals devoted to hygiene and medicine not usually read by chemists". It was not until 1913 that he learnt about them, through books written by Vedder and Funk. Apparently keeping abreast of the literature presented problems in those days also, though not the same problems that confront the modern scientific worker.

The other reviews are generally of high quality, clearly summarizing existing knowledge. They differ, however, in their value to the average nutrition research worker. "The Biosynthesis of Vitamin C", by C. J. King and R. R. Becker, deals with a very specialized field and the same may be said of "Neoplasia and Nutrition", by T. A. McCoy. The articles "Treatment and Prevention of Kwashiorkor" by a group of workers at the Institute of Nutrition for Central America and Panama, and "Nutritional Factors in Anæmia", by G. R. Wadsworth, are of wider general interest. "Basal Metabolism in the Japanese Population", by Shinjiro Suzuki, brings out the fact that the body size of the Japanese has steadily increased since 1900, with an interruption associated with war and post-war food shortages; this review is agreeably but rather unnecessarily enlivened by a photograph of two attractive Japanese women divers. The last review in the volume, by A. Giroud, on the nutritional requirements of embryos, is unusual and informative; in spite of 350 references the author succeeds in giving a lucid account of a recently developed field of research likely to be of considerable practical significance.

It is difficult to assess the contribution which this "World Review" is likely to make to nutrition research and applied nutrition and to judge whether it will fulfil a real need. The editor has undertaken a formidable task and faces much competition in the shape of other review journals of longer standing. The first volume sets a high standard which may not be easy to maintain.

W. R. Aykroyd

PLASMA PROTEINS

The Plasma Proteins

Edited by Frank W. Putnam. Vol. 1: Isolation, Characterization and Function. Pp. xv+420. Vol. 2: Biosynthesis, Metabolism, Alterations in Disease. Pp. xv + 518. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) Vol. 1, 12.50 dollars; Vol. 2, 14.50 dollars.

THE objective of this treatise was to provide an account of the physical and chemical properties of the plasma proteins, their function, biosynthesis, metabolism and alteration in disease. To attempt to produce an authoritative and up-to-date work on such a vast subject is a tremendous undertaking requiring the utmost co-operation between editor, authors and publishers.

We are told by the editor in his preface that the entire treatise was completed within eighteen months of the first invitation to the authors, and that Volume 1 was published within one year of the first deadline for manuscripts. This is probably true also for Volume 2 which followed only a few months afterwards. Those of us who have had to wait two years and often much longer for our articles to appear in print in collective volumes will be enviously impressed.

There is no doubt that this publication has succeeded admirably in its objective. It is impossible to do justice to it in a short review; but a glance at the chapter headings and the names of the authors, all of whom are experts in the fields they write about, will give some idea of the extent and authority of treatment. The first three chapters are on methodology, and deal with fractionation and isolation by precipitation techniques (R. B. Pennell), electrophoretic and ultracentrifugal methods (G. R. Cooper) and ion-exchange chromatography (E. A. Peterson and H. A. Sober). Molecular parameters of purified plasma proteins are then discussed by R. A. Phelps and F. W. Putnam. Then follow detailed discussions of individual and particular groups of plasma proteins (albumin, by J. F. Foster; γ-globulin and antibodies, by R. R. Porter; macroglobulins and antibodies, by H. G. Kunkel; glycoproteins, by R. J. Winzler; metal binding proteins, by C. B. Laurell; lipoproteins, by F. T. Lindgren and A. V. Nicholls; plasma enzymes, by W. H. Fishman, and circulating hormones, by H. N. Antoniades). R. G. MacFarlane contributes an article on the very complex blood coagulation system. Emphasis throughout the treatise is on human plasma proteins, but there is a chapter by R. L. Engle and K. R. Woods on comparative biochemistry and embryology, wherein data for many species are presented. Biosynthesis is covered by H. S. Anker. Alteration in disease occupies two chapters; M. L. Peterman describes altered patterns and F. W. Putnam surveys the properties and biosynthesis of abnormal globulins. Finally, genetic alterations in human plasma proteins are described by D. Gitlin and C. A. Janeway.

All this mass of material is brought together for the first time in English, and treated from the modern experimental point of view. Despite the large number of contributors there is no serious duplication and there are frequent cross references from one chapter to another. The subject-matter is presented in a logical way, and continuity is preserved.

Despite recent and rapid advances in some of the fields discussed, the comprehensive treatment, wealth

of tabular data and the many references give this treatise a lasting value. Not unimportant is the clarity of style; most of, if not all, the chapters can be read with pleasure as well as for instruction. All this is a tribute not only to the authors but above all to the editor.

This treatise will be of the greatest value to all who have anything to do with plasma proteins; it is undoubtedly a major contribution to the literature on proteins.

R. CONSDEN

FERNS, MOSSES, SHRUBS AND TREES

British Ferns and Mosses

By Peter Taylor. (The Kew Series.) Pp. 231+15 plates. (London: Eyre and Spottiswoode (Publishers), Ltd., 1960.) 25*s*. net.

Garden Shrubs and Trees

By S. G. Harrison. (The Kew Series.) Pp. 318+15 plates. (London: Eyre and Spottiswoode (Publishers), Ltd., 1960.) 25*s*. net.

THESE new volumes in the Kew Series on British plant life are uniform in format and outlook with the two already published, and maintain the same rather humdrum level. At just one point the atmosphere changes. Mr. Taylor's account of the horsetails occupies some 32 pages, and one is immediately aware of his personal enthusiasm for this much neglected group. Backed up as it is by Miss Webster's admirably clear illustrations, this is surely the best account available and is one that every British botanist and field naturalist will wish to have at hand. The ferns themselves are displayed competently but unexcitingly. There is a resolute determination in this series not to frighten any reader by too much modern science. It is a misguided attitude. Sir Joseph Hooker knew better, and in the preface to his "Student's Flora" referred to "those physiological and morphological observations on British plants which have of late given so great an impulse and zest to botanical pursuits". He regretted that he could not fulfil his original intention of giving details of such work. The incorporation of the results of Prof. I. Manton's magnificent experimental studies on British ferns in a popular book of this kind is just what is needed to give a fillip to field botany.

Any selection of material invites criticism, and Mr. Harrison's choice in "Garden Trees and Shrubs" cannot escape it. How could he include *Erica carnea* and omit *Calluna*? Or mention six species of *Magnolia* and not one of the beautiful *M. sieboldii–M. wilsonii* group? Also, why no single yellow rose (such as *R. hugonis* or *R. xanthina*) to stand beside the red *R. moyesii*? These are strange omissions in the presence of *Decaisnea fargesii* and *Griselinia littoralis*. The chosen plants are, however, neatly and lucidly described, and the book, with its pleasant coloured illustrations, will yield some informative browsing for botanically minded gardeners. It is not really a book for identification purposes, for the key will often work only for the actual species described, and a different one may come down to the wrong genus. *Ledum* (keyed out on p. 37) has free petals and should be placed next to *Skimmia* and *Cotoneaster* on the previous page.

The black-and-white figures in this volume leave something to be desired: the characteristic pattern of the leaves of *Coriaria* (Fig. 24) has been quite lost, and the upright shoot of *Halesia* (Fig. 45) gives no idea of the gracefully pendent flowers; *Taxus baccata* var. *adpressa* (Fig. 65) looks far more like a species of *Pernettya*. It is not, however, the minor defects of this series which one regrets: it is the faint atmosphere of stagnation. Current interest in wild and cultivated plants is more lively and inquiring than the authors seem to realize.

B. L. BURTT

MICROSCOPIC STAINS

Encyclopaedia of Microscopic Stains

By Edward Gurr. Pp. xii+498. (London: Leonard Hill (Books), Ltd., 1960.) 95*s*. net.

THIS book is to be regarded as an F_1 hybrid (Conn × Colour Index). It retains the characteristics of both parents, being intermediate in size between the slimmer Conn and the stout Colour Index (first edition), and deriving its style and format largely from the former.

Most of the book (420 out of 498 pages on very thick paper) takes the form of an alphabetical list of dyes, together with synonyms, molecular weights, empirical and structural formulæ, and solubility data. These last, giving solubilities in water, ethanol, 'Cellosolve', ethylene glycol and xylene, are particularly useful in practical histology.

Each dye is listed with a number and trade mark ('Michrome') so that, although no price is mentioned, an aura of the catalogue overhangs the whole work. In his preface the author defends his own system of numbering on account of its stability by comparison with alternative systems (the second edition of the Colour Index differs widely from the old one). If the constancy of the dyes listed is as good as that of the numbering system there is much to be said in its favour.

The descriptive notes which accompany each listed dye give numerous references to possible and actual uses, but, in a disconcertingly large number of cases, the author has been unable to find any histological or histochemical use to justify the inclusion of the dye in his lists. In some cases dyes with identical formulæ, molecular weight and solubilities are recorded as separate items, without the appropriate synonym (brilliant crocein; croceine scarlet).

The author makes a case for regarding the molecular weight of a dye as an important indicator of its properties. He therefore presents, at the end of the book, a table of molecular weights as an aid in "selecting dyes for particular purposes".

Two other sections, perhaps added as an afterthought, briefly concern the diazonium salts used in histochemistry and the tetrazolium salts similarly employed. In the case of the former the quoted molecular weight is relatively useless unless the concentration of vehicle and stabilizer in the commercial product is known.

Histological departments and students of histology may like to have this book on their shelves; it contains a large volume of interesting and necessary information.

SYNTHESIS OF APPLIED PALÆONTOLOGY

Paléontologie Stratigraphique
Par Prof. H. Termier et G. Termier. Pp. ix+515. (3,425 figures). (Paris : Masson et Cie., 1960.) 148 N.F.

Atlas de Paléogéographie
Par Prof. Henri Termier et Geneviève Termier. Pp. 100, avec 36 figures en couleurs et 8 figures. (London : Masson et Cie., 1960.) 16 N.F.

THERE is in geology a great need for the publication of comprehensive works which draw together and synthesize the vast quantities of observational detail which have been rapidly accumulating in the past decades all over the world. Similarly there is a need for the critical comparison and co-ordination of the innumerable ideas and speculations that have been published in original papers in a great many different fields. We ought to be truly grateful to those who are prepared to step out of the fray (where glory is won), survey the field and report on the state of the battle. The task they perform is seldom rewarding to themselves, while the works they write involve a great deal of labour. Unfortunately the need for such works and their rarity make us very critical, for so often when they are published we are disappointed to find they are not those for which we were waiting.

Thus we ought to be delighted with these two excellently produced volumes by the indefatigable team of Prof. and Mme. Termier. However, there is no doubt that in spite of the really excellent drawings of the "Paléontologie Stratigraphique" and the equally beautifully executed maps of the "Atlas de Paléogéographie" a feeling of disappointment is not to be avoided.

The "Paléontologie Stratigraphique" is neither palæontology nor stratigraphy. It consists chiefly of a collection of figures of fossils arranged chronologically, and it attempts to survey the whole faunas and floras of each System, the larger Systems being broken down into Lower and Upper, or Lower, Middle and Upper. The matter is to some extent further organized by an introductory article on each System, or division of a System, dealing with the faunas or floras characterizing particular major facies developments. Tables of zones are provided at the end of each section. It is of course not possible to be truly comprehensive even in 515 pages and with 3,425 figures. The choice of genera for treatment is eclectic. Some are important zoologically, others as zone fossils, and many are merely abundant. In consequence neither the evolutional nor the purely stratigraphical account is as complete as it could have been if it alone had been the object of the book. This is in fact a museum in a book, and for the student who has not access to a really good palæontological collection it can be a really valuable reference book (though he will not be able to afford to buy it for himself). For an encyclopædic work of this kind it is exceptionally accurate and up to date. A weakness, however, is the lack of any indication of the magnification of a large number of figures which differ greatly in size from the originals.

The "Atlas de Paléogéographie" consists of 36 maps—each a Mercator projection of the whole world—which originally appeared in the first volume of the authors' "Traité de Géologie". These maps differentiate, at successive stratigraphical horizons, subsiding and non-subsiding seas (in two tones of blue) and show by means of pictographs the distribution of vulcanicity, mountain ranges, coral reefs, forests and other geographical features as well as particular fossils. Arrows show the direction of migration of faunas and floras. Had the maps merely summarized the broad distribution of the regions of thick sedimentary accumulation in the past, and the known distribution at particular times of other sedimentary phenomena and of particularly significant fossils, they might have had some value. But the maps purport to do much more than this; and to the extent that the reader accepts them as established geographical reconstructions and interpretations of migration routes, so is he misled. Moreover, on account of the small scale of the maps compared with the size of the symbols, together with the fact that the maps do not represent true instants of time, an altogether false impression is presented of the extent of the available data. In the hands of an undergraduate, or of a layman, this can be a dangerous book. The experienced stratigrapher will prefer his own speculations.

S. Simpson

METALS IN SURGERY

Metals and Engineering in Bone and Joint Surgery
By Prof. Charles Orville Bechtol, Prof. Albert Barnett Ferguson and Prof. Patrick Gowans Laing. Pp. vii+186. (London : Baillière, Tindall and Cox, Ltd., 1959.) 64*s*.

SINCE the earliest times the surgeon has been in need of some inert material which he can introduce into the body to unite damaged tissues, or to replace structures that are beyond repair. Over the years, however, implantation of a wide variety of metals gave disappointing results, owing either to the mechanical failure of the implant or to its inflammatory effect on the surrounding tissues. Not until shortly before the Second World War was it realized that this lack of success was due to metallic corrosion, and even later before the part played by such factors as fatigue and fretting was really appreciated. It then became apparent that the orthopædic surgeon had to be not only a master of his own art, but also conversant with the crafts of the physical chemist and the engineer.

It is this extra knowledge, in concise and palatable form, that the authors of this book set out to give him. Starting with a brief survey of the historical aspects of the subject, with adequate references, they pass on to consider the theory of metallic corrosion, at first in general terms, and then as applied to the various metals that have found application in surgery, indicating how such corrosion may be exacerbated by the incorrect choice or treatment of the metal to be implanted. Next they consider the structure and mechanical properties of bone, and show that a thorough understanding of such properties is necessary for the correct design and use of metallic implants. Finally, they discuss the healing process as applied to fractures, and describe in detail the various ways in which metals may be used for the internal fixation of broken bones.

Any attempt to correlate three such different disciplines as surgery, electrochemistry and engineering must of necessity result in a treatment which to a specialist in any of these subjects may appear as superficial. It might possibly be argued that a book of this kind would have been of more value had it been written with the collaboration of a chemist and an engineer. Such collaboration, however, might well have resulted in a treatment too long and detailed to be of practical use to the surgeon for whom, after all, the volume is intended.

The book is well illustrated, with many references to the original literature; and while the reviewer might point to a few minor blemishes such as the misspelling of his own name, such slips in no way detract from a work that should be of real value to those for whom it is written. E. G. C. CLARKE

RHEOLOGY

Rheology

Theory and Applications, Vol. 3. Edited by Frederick R. Eirich. Pp. xvi+680. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 21 dollars.

"EIRICH" is already a classic in rheological literature, even if it cannot be said to have brought about "a better understanding of the essential unity of rheology"; a hope expressed in the preface to Vol. 1.

The present volume contains little that will unify; rather it consists, like its predecessors, of a number of disconnected essays, differing somewhat widely in merit, on applications of rheology to various systems. It has still not been possible to establish an agreed set of symbols, even for the most widely used terms; but, unlike some of the chapters in previous volumes, each of these essays includes an adequate table of the author's choice of symbols.

Vol. 3 contains less material already published in book form by the same authors than did its predecessors; but there are still many pages of repetition of well-known classical treatments already available in other text-books. This reflects vestiges of the earlier idea, which can scarcely be maintained, that this excellent series of books would prove not only necessary but also sufficient for many rheologists.

Following these general criticisms, it is right to say that many of the essays are really admirable. Especially praiseworthy are the first three chapters: B. H. Zimm's essay on polymer chain models for dilute solutions; S. Oka on principles of rheometry; and B. E. Conway and A. Dobry-Duclaux's description of electroviscous effects.

Chapters 4–10 are concerned with the applications of rheology to different materials: latex, printing ink, pastes and paints, sand– and clay–water mixtures, inorganic glasses, concrete, and cross-linked polymers.

The "Atomistic Approach to the Rheology of Sand–Water and Clay–Water Mixtures", by W. A. Weyl and W. C. Ormsby, reflects the almost compulsive urge of some rheologists to insist on an 'atomic', as distinct from a phenomenological, explanation of all experimental data. Rheology, like all other branches of science, is concerned with generalizing, co-ordinating and relating diverse phenomena. In many cases an 'explanation' in terms of molecular structure is both possible and desirable. Other phenomena, such as those dependent on the conditions of packing of large aggregates, do not readily lend themselves to an 'atomic' approach. The authors of this chapter seem almost ashamed that everything cannot be explained in atomic terms.

Chapter 11, by D. W. Criddle, is concerned with interface rheology, and the remaining five chapters deal with industrial processes in relation to lubrication, adhesion, moulding, spinning and screw extruding.

The volume is very expensive, but the production is excellent, and there appear to be few misprints. It is good to learn that it is likely that this will not be the last volume of "Eirich". So far, scarcely any mention has been made of biological systems. A volume, or at least a part of a volume, devoted to biorheology would now be useful, since it would seem to be about eight years since any text-book has appeared on this subject, and much work has been done meanwhile. G. W. SCOTT BLAIR

CONSTANTS OF BINARY SYSTEMS

The Physico-Chemical Constants of Binary Systems in Concentrated Solutions

By Prof. Jean Timmermans. Vol. 3: Systems with Metallic Compounds. Pp. xiii+1322. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 270*s*.

THE preparation of this volume was supported by a grant from the Union Minière du Haut-Katanga, which is especially interested in this kind of binary system. Although more than half this book is devoted to tables of the properties of binary systems of which water is one component, no solubility data as such are listed. Presumably the author did not wish to include information already collected elsewhere (for example, in Seidell's tables): but nevertheless solubilities do appear in a disguised form as freezing curves. However, the information on freezing curves is not as useful as it might be because the solid phase in equilibrium with the solution is not often indicated. These omissions are particularly unfortunate since freezing curves represent a large proportion of the data.

The notice to users claims that the same properties are tabulated as in the earlier volumes (see *Nature*, 186, 918; 1960); but in fact scattered information is included on other properties such as activities, lattice constants, Verdet's constant, X-ray absorption, osmotic coefficients and the compositions of isopiestic solutions. For some systems values of these quantities are given, but for others only the name of the author and a date are listed.

The compilation is not a critical one and there are considerable discrepancies among the tabulated values. The author in the preface ascribes these errors to inadequacies in the measuring apparatus as well as to the use of impure specimens. Considering the early date of many of the values included it is not surprising that there is some lack of agreement.

This volume is even more expensive than Volumes 1 and 2, and like them, it will probably not be purchased by many private individuals. Every science

library should possess a copy, however, because when Volume 4 (containing the bibliography and index) is available, the use of this book will save much time in searching the literature.

E. F. G. Herington

FROZEN FREE RADICALS

Frozen Free Radicals

By Dr. G. J. Minkoff. Pp. ix+148. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 5 dollars; 36*s*.

FREE radicals are highly reactive species, but many radicals can be successfully immobilized in solid matrixes at low temperatures. In the past ten years the development of new techniques has led to a great acceleration of the study of the formation and trapping of radicals. This has been encouraged by the initiation in 1956 of a three-year programme of fundamental research at the National Bureau of Standards, where it was hoped that it would prove possible to utilize the stored energy of a high concentration of free radicals in the production of an efficient rocket fuel. Dr. Minkoff spent a year as a guest scientist at the National Bureau of Standards in connexion with this programme.

Drs. Bass and Broida of the National Bureau of Standards have recently edited a volume of sixteen contributions on the history and modern development of radical trapping, which is at present the most exhaustive review of the subject. In contrast, Dr. Minkoff's monograph can be particularly recommended as a well-co-ordinated introductory survey.

The first four chapters of the book are devoted to the history of radical trapping and a description of the modern techniques. Many of the early studies of the phenomena of light emission from the condensation products of discharges and of the reactions taking place in cold traps have been repeated. The stabilization of free radicals has been increased by the use of liquid helium as refrigerant, and descriptions are given of several Dewar vessels constructed for optical studies at liquid-helium temperature. Several methods for the detection of free radicals are given, with indication of their suitability for use when the radicals are trapped. Electron spin resonance has proved particularly valuable in this respect. Statistical predictions have been made of the maximum concentration of free radicals that may be trapped in various assumed models. However, all but one of these give limits which are much in excess of the experimentally determined maximum of a few tenths of 1 per cent as they do not allow for the nature of the matrix or the energy of recombination of the radicals.

The last three chapters of the book summarize the most important experiments published up to early 1959. Many pages are devoted to the observations on nitrogen atoms, as the repetition and extension of the early work gave much stimulus to the National Bureau of Standards programme. Atoms and small radicals have usually been produced in the gas phase and condensed at liquid-helium temperature. However, larger organic radicals are better stabilized by the irradiation of suitable solid solutions with ultra-violet or ionizing radiation. Liquid nitrogenh as usually sufficed as refrigerant in these experiments, in which the radicals may be the primary products of the irradiation or the results of reactions by the primary products. Free radicals have been found to be trapped in polymers, and are also believed to be important in biological systems. Reduced temperature is not necessary in these cases, and they are only briefly mentioned.

R. N. Dixon

NATURAL HIGH-POLYMER CARBOHYDRATES

The Chemistry of Plant Gums and Mucilages and some related Polysaccharides

By Prof. F. Smith and Prof. R. Montgomery. (American Chemical Society Monograph Series, No. 141.) Pp. x+627. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 144*s*. net.

PLANT gums and mucilages are complex carbohydrates and rank among the oldest articles of commerce. They are abundant and their applications are diverse, so that their use and importance are growing. The fairly recent unravelling of major parts of their complex structures provides a fascinating story, so that the appearance of this monograph is opportune.

The senior author, F. Smith, is one of the world's leading experts in the field, and the junior author is a well-known carbohydrate chemist—both of Haworth's Birmingham School—so that much was expected from them. Their labour and care are rewarded, for the book fully justifies the claim of the publishers that it contains everything that is known of these substances.

The first few chapters deal in a human and interesting manner with the function and origin of gums, their classification, isolation, detection and identification. A wealth of detail is provided, some of which, however, except for its historical importance, could perhaps have been omitted. Methods for the separation of polysaccharides generally are concisely described, and their analytical procedures are covered in a very long and exhaustive chapter. The rest of the book is devoted to the detail of the determination of the structure of the many gums, mucilages, exudates, etc., so far examined. The importance of periodic oxidation techniques and of methylation procedures, largely pioneered by the senior author, is brilliantly emphasized, and seeing the picture as a whole one is amazed at the wealth of knowledge we now have of these complex high-polymer carbohydrates.

Of particular value in connexion with structural work in the field is the provision of an appendix giving some of the physical characteristics of all the *O*-methyl derivatives of monosaccharides.

An important innovation is the account of studies of gum structure by means of specific immunological reactions which provide diagnostic micro-methods of growing importance.

The book is full of beautifully drawn formulæ which make it of special value to the non-expert. It contains a most valuable series of references, and it is excellently printed and free from errors.

It will form a valuable addition to the library of every chemist, biochemist and plant physiologist, and can be highly recommended.

M. Stacey

ENZYMES AND METABOLISM

Advances in Enzymology and Related Subjects of Biochemistry

Vol. 21. Edited by F. F. Nord. Pp. v+521. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 12.50 dollars.

THIS volume of "Advances in Enzymology" contains a very important set of articles on some important lines of metabolism which have only recently been elucidated. The synthesis of purines and pyrimidines is covered by three reviews which supplement each other: "Enzymic Reactions in the Synthesis of Purines", by Drs. Buchanan and Hartman; "The Enzymic Synthesis of Pyrimidines", by Dr. Reichard; and "Folic Acid Coenzymes and One-Carbon Metabolism", by Drs. Huennekens and Osborn. In the past ten years the main lines of synthesis have been cleared up, with an appreciable increase in the number of known enzymes; some new and interesting enzymatic mechanisms are involved, and these are discussed critically in the first-mentioned article.

Other metabolic topics dealt with in the volume are oxidation and phosphorylation (in two reviews, by Dr. W. C. Schneider and Dr. D. E. Green, respectively) and the biosynthesis of carotenoid pigments (by Dr. T. W. Goodwin). Schneider's article reviews work on mitochondrial metabolism up to about 1957. Green's article is primarily concerned with the work of his own school on electron transport, which is discussed in terms of the special terminology which they have developed to express their view of the structural organization of enzymes in mitochondria. The enzymology of carotenoid metabolism is not as yet far developed, and Goodwin's contribution is necessarily mainly concerned with the chemistry of these plant products.

Two articles are concerned with the role of metals in enzymatic systems. Drs. Malmström and Rosenberg discuss (in English) the mechanism of metal ion activation of enzymes; Prof. Bamann and Dr. Trapmann are concerned (in the only article in German in this volume) with reactions in which metal ion catalysis may be regarded as a model of the enzymatic catalysis. They give an excellent picture of the field, but leave the impression that much remains to be done.

This volume will clearly remain for some time to come a standard reference for the topics discussed therein.

EDWIN C. WEBB

CONDUCTION IN SOLIDS

Electrons and Phonons

The Theory of Transport Phenomena in Solids. By Dr. J. M. Ziman. (The International Series of Monographs on Physics.) Pp. xiv+554. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 84s. net.

LITTLE more than four years elapsed after the discovery of wave mechanics before the basic principles of electrical and thermal conduction in metals were established, and such was the speed of the advance that within another four years, up to the end of 1934, the properties of individual metals, and even alloys, were being successfully analysed in terms of the new theory. The War brought progress in this field almost to a standstill, but at its end a new generation of physicists with new techniques and new ideas took up the pursuit once more, and the past fifteen years have seen a vast accumulation of detailed information on the properties of solids of many kinds. Although during this time there has been little change in the underlying principles or even in the mathematical methods employed in the electron theory of solids, yet so great a refinement of treatment has been introduced and so many more experimental effects discovered that, as the author of the book under review states in his preface, it is now probably beyond the capacity of any one man to write alone a satisfactory account of the whole theory.

In his book Dr. Ziman has confined himself to an account of the transport properties of metals, semiconductors and insulators; a subject of which he is undoubtedly a master. The title of the book at once indicates the quantal aspects of the conduction processes. By analogy with the quantized electromagnetic field it has become fashionable in recent years to refer to quantized elastic waves in crystals as phonons, and the whole mechanism of conduction is visualized as the mutual interaction between the phonons themselves and between phonons and electrons. This is an attractive picture, but it can all too easily suggest an over-simplification to the incautious reader: unlike a photon, the nature of a phonon in an elastically anisotropic crystal depends on the direction of its motion. The scattering of an elastic wave in a crystal is a more complicated process than that suggested by the deflexion of a single entity described as a phonon.

In an interesting analogy the author likens the writing of a scientific text-book to the process of purification by recrystallization. The imperfections of original papers are filtered away and the precipitate forms as a crystal in which each atom seems inevitably to be in its right place. This is a flattering description, and many of those with experience of either reading or writing text-books would hesitate to compare them with the perfect crystal. Dr. Ziman's is an excellent book but it will no doubt share the common lot and in the fulness of time will require extensive modification and revision. To the present generation of students—of all classes—the book will surely prove invaluable. It develops a theory in a clear and logical manner; dealing first with the properties of phonons, then with the properties of electrons in a periodic field, and eventually with the interactions between these systems. In this way is unfolded the theory of thermal conduction in insulators, the theory of thermal and electrical conduction in metals, the effect of an external magnetic field on the resistivity, the de Haas–van Alphen and the anomalous skin effects, and much besides.

The mathematics of the book is kept within reasonable bounds although always sufficiently detailed to enable the diligent reader to follow the argument completely. Physical concepts are emphasized, and the book abounds with discussions of significant experiments. The style is graceful, and erudite quotations at chapter headings are provided for the diversion of the reader. The publishers, for their part, have done a good job: the type is clear and the diagrams beautifully reproduced. Altogether this is an excellent book and deserves to be widely read.

H. JONES

GAS DISCHARGES REJUVENATED

Plasma Physics

By J. G. Linhart. (Series in Physics.) Pp. xi+278. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1960.) 50*s*.

Basic Data of Plasma Physics

By Prof. Sanborn C. Brown. (Technology Press Books in Science and Engineering.) Pp. viii+336. (Cambridge, Mass.: The Technology Press of the Massachusetts Institute of Technology; New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 52*s*. net.

THERE cannot be many examples in the history of physics of an almost moribund branch reviving and blossoming with such vigour as happened in the past ten years to what used to be called 'conduction of electricity through gases' or 'electric gas discharges'. The resurrected science is called 'plasma physics', adopting the name which Irving Langmuir gave almost forty years ago to the tough 'substance' of gas discharges, the highly ionized, highly conducting gas. The revival was due in the first place to the hope of controlled fusion, and led in a few years to giant devices such as *Zeta*, *Stellarator* and *Ogra* which dwarfed not only the modest discharge tubes in which J. J. Thomson and Langmuir made their classical discoveries, but also the largest rectifiers ever made for power stations. It is now common knowledge how successful the plasma was in repelling these first attempts for heating it up to millions of degrees, how it managed to dissipate the energy by processes nobody had thought of. This led to a general sobering and a determination to study the plasma before trying to force it to do what it so evidently dislikes doing. There may be some legitimate doubt whether it will be ever possible to 'study the plasma' except by feeding energy into it in special configurations of electromagnetic fields, and whether such knowledge will ever add up to a general mastery; but the intention is certainly laudable.

It can be said with confidence that at the present there exists no better introduction to this complex subject than Dr. Linhart's book. The author has the three rare qualifications of experience, mathematical facility and inventive imagination. He also possesses didactic ability, but this will be appreciated only by those readers who share with him the advantages of mathematical ability and of an active mind. It is not a book which can be imbibed passively, or uncritically.

The first three chapters on motion of electrons and ions, fluid description of plasmas and equilibrium configurations are more or less conventional and will make fairly easy reading for postgraduate physicists. The author comes into his own in the far more difficult chapters on waves and instabilities, shock waves and relaxation processes. Unfortunately, the derivation of the Fokker–Planck equation is almost incomprehensible, which is particularly regrettable in a subject in which Einstein and Debye have created masterpieces of simple exposition. This, however, is a rare exception in Linhart's book. The final chapters on research on controlled fusion and other applications, though perhaps somewhat too brief, make excellent reading.

Prof. Sanborn Brown's book on "Basic Data of Plasma Physics" is not only an excellent text-book on the more orthodox chapters of gas discharges, but also a reference book which one cannot afford not to have on the shelf. Many of the most valuable data in his book (on high-frequency breakdown, on diffusion and recombination) are the results of the researches of its author and of his collaborator, Manfred Biondi. While much of the material on elementary processes is covered also by Massey and Burhop's "Impact Phenomena", about one-half of the book which deals with breakdown conditions and with discharges is a happy complement to that other excellent work. The arrangement is so clear, with full description of the experimental methods and with all the relevant theory required to explain the data, that the book can be equally recommended to the student and to the expert research worker. D. Gabor

HYPERSONIC FLOW PHENOMENA

Hypersonic Flow Theory

By Wallace D. Hayes and Ronald F. Probstein. (Applied Mathematics and Mechanics, Vol. 5. Series of Monographs prepared under the auspices of the Applied Physics Laboratory, The Johns Hopkins University.) Pp. xiv+464. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 11.50 dollars.

THIS book will prove invaluable to the increasing number of students and research workers who are becoming interested in hypersonic flow phenomena. Although it is mainly theoretical, it is not such that it requires the reader to have very advanced mathematical knowledge. It should appeal to the engineer who has to tackle the practical problem of hypersonic flight just as much as to the physicist who wishes to acquire a physical understanding of hypersonic flow phenomena. Both authors have over the years made important contributions to hypersonic flow theory and are by experience fully qualified to write authoritatively on this subject, and thus to convey some of the knowledge they have gained in this important field of research, to interested readers of their book. Much of the material presented has not been published elsewhere and reference is also made to many Russian papers on hypersonic flow problems. Some of these are discussed in detail in the text.

The scope of the book is fairly wide, but it does not include any material on high-temperature gas dynamics and magnetogasdynamics. Throughout the text emphasis is laid on fundamental aspects of hypersonic flow and on the development of a soundly based theory. Semi-empirical theories are generally avoided except those which contribute in some way to the understanding of hypersonic flow phenomena. Theories which are based on wrong assumptions are not discussed though they may give good agreement with experiment.

In more detail, Chapter 1 is devoted to the consideration of the general features of hypersonic flow and some of the basic concepts used in the development of the theory. Chapter 2 is concerned with what is referred to as the 'small disturbance theory', as distinct from linearized theory, in relation to flow past slender bodies and gives similarity rules for determining the flow. Special reference is made to van Dyke, who first used the expression 'small disturbance theory' in his studies of flows in which the disturbances in velocity and pressure are small

compared with the velocity of the free stream and its dynamic pressure, but are not small compared to the velocity of sound and static pressure respectively, as is generally assumed in the conventional linearized theory. This chapter ends with a brief section on unsteady hypersonic flow and deals particularly with what is now generally known as 'piston theory'.

Chapter 3 is devoted to Newtonian theory and various modifications of it by Busemann, Lees and other writers. The theory is applied to two-dimensional and axi-symmetrical bodies and to the determination of optimum shapes. Shock layer structure and cross-flow phenomena are discussed, and a theory for unsteady Newtonian flow is developed. As first approximations to more general solutions based on the assumption that the shock layer is moderately thin, constant-density solutions are obtained in Chapter 4 which give information beyond that obtained from Newtonian theory. Cases considered include the wedge, the cone, the circular cylinder and Lighthill's solution for the sphere.

Chapters 5, 6 and 7 consider respectively the theory of thin shock-layers, blunt-body flows and shock-expansion theory, while Chapters 8 and 9 discuss hypersonic viscous effects. Chapter 10 deals briefly with free molecule and rarefied gas flows.

I would strongly recommend this book to students and research workers who wish to study hypersonic flow phenomena. W. P. JONES

GEOCHEMISTRY

Methods in Geochemistry

Edited by A. A. Smales and Prof. L. R. Wager. Pp. vii+464. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 13.50 dollars; 94*s*.

IN V. M. Goldschmidt's definition of geochemistry (1933) are implicit quantitative composition of the Earth and its parts, discovery of laws controlling distribution of elements, and comprehensive analytical data on rocks, meteorites, waters, atmosphere, to include geophysical evidence on the nature of the Earth's interior. This considerably extends the more restricted scope as originally enunciated by F. W. Clarke in his classical "Data of Geochemistry" (1908), where the solid crust of the Earth is the chief object of study. B. Mason, in his "Principles of Geochemistry" (1952), brings evolution of the subject to more recent times, when he defines the tasks of the geochemist as "the determination of the relative and absolute abundances of the elements and of the atomic species (isotopes) in the Earth" and "the study of the distribution and migration of the individual elements in the various parts of the Earth (the atmosphere, hydrosphere, crust, etc.), and in minerals and rocks, with the object of discovering principles governing this distribution and migration". Thus over the years both theoretical and analytical phases of geochemistry have expanded enormously, so, likewise, have the various methods of attack on the problems involved. In the present volume the authors, with collaboration of a team of specialists, describe modern techniques at the disposal of the geochemist which go far beyond traditional chemical and geological approaches to secure desired analytical data. "It is a long way from the geologist's hammer to the mass spectrometer and the nuclear reactor which are now sometimes the tools the analyst uses", as the authors naively remark in their introduction; what follows in this book gives all concerned a clear indication of how that gap is bridged to-day.

Modern geochemical methods include collection and preparation of material for analysis, here contributed by L. R. Wager and G. M. Brown. E. A. Vincent discusses gravimetric and volumetric analysis, flame photometry, colorimetry and related techniques. Spectrochemical analysis is dealt with by S. R. Taylor and L. H. Ahrens; fluorescent X-ray spectrography by H. I. Shalgosky; stable isotope geochemistry and mass spectrographic analysis by K. I. Mayne; mass spectrometric isotope dilution analysis by R. K. Webster; radiochemical methods by S. Moorbath; radioactivation analysis by D. Mapper; polarography by S. Moorbath and modern chemical separation methods by F. W. Cornish.

Of the above techniques, two comparatively recent procedures of remarkably high sensitivity have been added to the geochemist's weapons of attack available in geochemical analysis. One is the mass spectrometer isotope dilution method, which owes much to development of thermal ionization source mass spectrometers, also to present availability of separated isotopes of many elements; the other method is that of radioactivation analysis. Both procedures are adequately described in this book.

"Methods in Geochemistry" is a new departure in this science in that it is not only an up-to-date exposition of what the authors term "an almost embarrassingly wide choice of techniques for any given problem", but also because it brings together in one volume so much current information on geochemical research which chemist, geologist or physicist alike would have to seek in an otherwise voluminous international literature. The book is highly commendable, both in presentation and purpose. H. B. MILNER

MOISTURE IN TEXTILES

Moisture in Textiles

By Dr. J. W. S. Hearle and Prof. R. H. Peters. Pp. ix+203. (Manchester: The Textile Institute; London: Butterworths Scientific Publications; New York: Textile Book Publishers, Inc., 1960.) 40*s*.; 6.50 dollars.

THE adsorption of moisture by fibres is such an unobtrusive phenomenon that it is, perhaps, not generally thought of as being a reaction in the usual sense of the word. The interaction of the two is, however, of very great practical significance, not only because of associated changes in weight, which are economically important, but also because of dimensional changes in yarns and fabrics consequent on fibre swelling. The mechanism of moisture adsorption is complex and the many theories which have been evolved are admirably surveyed in this book, which is based on a series of lectures given at the Manchester College of Science and Technology.

The book is arranged in thirteen chapters, written by seven contributors. Chapter 1 (P. S. H. Henry) deals with water in the atmosphere and the relevant definitions; seasonal and diurnal variations; and the insulating effect of buildings. This is followed by

a brief chapter (J. W. S. Hearle) on the structure of fibres. The measurement and interpretation of sorption isotherms are discussed in Chapter 3 (A. R. Urquhart), the emphasis being on cotton. Factors which affect sorption, particularly mercerization, are included. Chapter 4 (W H. Rees) concerns heat of absorption, and thermal quantities are defined and interpreted, together with methods of evaluation; again, the effects of physical and chemical modification such as orientation, mercerization and acetylation are discussed. Chapters 5 and 6 (G. King) survey respectively two- and three-phase adsorption theories, and theories of multilayer adsorption. Rate of change of moisture content, the simultaneous diffusion of heat and moisture, and diffusion of moisture and solvents in fibre-forming substances such as sheet films and polymers are discussed in Chapters 7, 8 and 9 (J. Crank). These phenomena are of considerable practical importance in the bulk storage of textiles, and the theoretical treatment is directed to clarifying the basic mechanisms and to showing how the times of moisture transfer into or from any given package can be estimated from measurements on a standard package. In Chapter 10 (J. W. S. Hearle) the electrical properties of fibres are discussed, including the relation between dielectric constant and regain; the generation and dissipation of static electricity; and the electrical measurement of moisture content. Particular attention is paid to ionic theories of conductance. Chapters 11 and 12 (R. Meredith) are concerned respectively with the effects of moisture on the density and optical properties of fibres, and on the mechanical properties such as tensile and torsional strengths, creep, relaxation, and shear strengths. In the final chapter (J. S. W. Hearle) the retention by fibres of liquid water and the theoretical and practical aspects of removing water from fibrous masses by centrifugal and suction methods are surveyed.

The subject-matter is well presented and is accompanied by an excellent bibliography. J. W. Bell

FRENCH WITHOUT TEARS

An Introduction to Machine Translation

By Émile Delavenay. Pp. ix+144. (London: Thames and Hudson, Ltd., 1960.) 25*s*. net.

SEVERAL books on the mechanical translation of language have now appeared, generated in England, the United States, and the U.S.S.R. Hitherto, however, work in this field on the Continent has been singularly lacking, and, although in the past two years groups have started in the field, in France and in Italy, M. Delavenay's book is the first popular exposition of the French point of view which has been translated into English.

To say that the book follows well-trodden lines would be to do it less than justice, because any expository book must tend to do this. What is perhaps more important is that M. Delavenay's racy style has survived translation (by himself and his wife) and enlivens the reading of what can otherwise be somewhat dull matter.

The book starts with a few general remarks about the nature of translation and, in particular, about the impact of information theory on this art. Here, unfortunately, M. Delavenay allows his enthusiasm to get the better of him in suggesting that information theory is of great importance to machine translation. The fact is that information theory considers the statistical aspects of communication, but nowhere, so far as I know, does it make any reference to meaning, and meaning is the essence of translation.

After this somewhat philosophical start the book runs smoothly through aspects of computing machines and their relevance to the translation of language. It states clearly how a computer works, explains the coding into numerical form which is necessary to transform words into arithmetical quantities for processing in a computer, and then it goes on to discuss various aspects of computer processing of language.

After these preliminaries there is a historical approach. M. Delavenay, quite rightly of course, mentions the original Russian patent of Trojanski dated 1933, although he, like all other Western experts in this field, appears to have seen only the title page. He then goes on to trace the history up to 1955, and to indicate the way in which this subject has grown from an unimportant sideline in certain university laboratories to a large-scale activity in which some thousands of scientists are involved.

After this history there is an account of languages and of meta-language, and also an indication of how linguistic analysis can be performed on a machine. Much of this work follows the lines laid down by the Russian school of machine translators. M. Delavenay in this account makes a number of succinct comments on the virtues of the Russian approach to machine translation and seems much impressed by the Russian development of what is effectively a meta-language.

The next subjects to receive attention are syntax and morphology, and here in discussing the question of reducing storage requirements by the use of micro-glossaries, M. Delavenay gives an interesting example of a partial German translation in which only the most frequent words were translated, with the result that no meaning at all comes through, or alternatively in which only the technical words are translated, in which case the meaning is completely clear without any very good notion of what connecting words are present. This is, in a sense, a validation of the early work of Richens and myself, who proposed to ignore sentence structure and grammar completely and to concentrate on evaluating the technical meanings.

Having dealt with syntax, the last aspect of machine translation to be covered is that of lexical problems. Here there is a detailed consideration of different possible storage media, an indication of the way in which code compression can help in saving storage, an account of the processing of idioms, indications of means by which multi-meaning can be resolved and an analysis of the virtues and otherwise of the Thesaurus method. All these topics are of particular interest to specialists in the field, and it is useful to have the opinions of an expert who is not committed to any particular party-line on the relative merits of the different methods.

The book concludes with a look into the future, as M. Delavenay sees it, and finally, and most usefully, a long example of a machine translation from French into English.

There are a number of small errors which will irritate knowledgeable readers of this book. Many of the numerical data which are given are incorrect

for one reason or another. This does not appear to be due to ignorance on the part of the author because reference to the original French edition shows that the correct figures appear there. It is surely proof, if any is needed, of the virtues of a translating machine for technical material. Such a machine would certainly not have produced the lively text that M. Delavenay and his wife have done, but it would have ensured the factual accuracy of the figures which he gives. These blemishes are, however, quite minor, and the book can be unreservedly recommended as an introduction to this important art.

A. D. Booth

MATHEMATICS, GAMES AND ECONOMICS

Mathematical Methods and Theory in Games, Programming, and Economics

By Samuel Karlin. Vol. 1 : Matrix Games, Programming, and Mathematical Economics. Pp. x+433. Vol. 2 : The Theory of Infinite Games. Pp. xi+386. (Addison-Wesley Series in Statistics.) (London : Pergamon Press ; Reading, Mass. : Addison-Wesley Publishing Company, 1959.) 75*s*. net. each volume.

THIS work is, in a broad sense, a contribution to the mathematics of decision making. Most of the material included is of recent origin, and the author himself has contributed substantially to the subject. It is concerned mainly with two-person zero-sum games. The subject-matter results largely from the research efforts of teams organized, or supported, by Stanford University, the California Institute of Technology, the Rand Corporation and the Office of Naval Research. As a result, mathematicians interested in this field, mathematical economists, and operational research workers will find the work almost indispensable, at least as a reference book, if they wish to be up to date.

Part 1 of the two-volume work is concerned with the theory of matrix games. Games are defined, the min-max theorem is presented, and the nature of optimal strategies for matrix games is considered. Various discrete games are solved, and these include an example from advertising where two political parties are engaged in an election campaign. Part 2, which completes Volume 1, is a comprehensive account of programming, both linear and non-linear. Computational methods are discussed, but not practical details, such as some of the problems which arise when an electronic computer is used ; attention is given rather to the theory of the computational method. In the chapter on linear programming there are sections, as one would expect, on transportation and assignment, and on the warehouse problem and the caterer's problem. There are two chapters on mathematical methods applicable to economic models. One is concerned with theories of production, consumption and equilibrium, the other with welfare economics, models of balanced growth, and the stability of the equilibrium of price vector systems.

The second volume is concerned with infinite games, and after an introductory chapter on the nature and structure of such games, considers games with convex kernels. Then there are two chapters on "Games of Timing", a name coined in 1950 for games of tactical duels. The study of the latter commenced in 1948 when the Rand Corporation "collected a team of mathematicians, statisticians, economists and social scientists to analyse the meaning and structure of 'the uncertainties of war' and to construct a blueprint for the optimal future operation of the economies of attack and defence in war". By now a great number of games of timing have been analysed, and something of a general theory has emerged. The volume concludes with chapters on infinite classical games and on poker and general parlour games. There is a very interesting analysis of the Le Her game, and it is evident that in various cases solutions are only now appearing of games of some antiquity.

Some general remarks may not be out of place. The work will be essential for anyone carrying out research in game theory or mathematical economics. But it will also be useful for students, especially new graduates entering this field. There is a comprehensive bibliography of more than 250 references and there are problems set at the end of each chapter together with solutions worked out in detail. One unusual feature is that Volume 2 repeats Chapter 1 of Volume 1, and also all the appendixes. These amount to more than one-fifth of Volume 2 and must increase appreciably the price of the volume. The reviewer can find little justification for this repetition, even though it is stated as having been done so that the volume may be read independently of Volume 1.

L. S. Goddard

WATER SUPPLIES FOR SMALL COMMUNITIES

Water Supply for Rural Areas and Small Communities

By Edmund G. Wagner and J. N. Lanoix. (Monograph Series, No. 42.) Pp. 337. (Geneva : World Health Organization ; London : H.M. Stationery Office, 1959.) 20 Swiss francs ; 35*s*. ; 6.75 dollars.

THOSE of us who live in highly organized communities in the humid regions tend to take water so much for granted that we sometimes overlook how vital a commodity it is to our existence. Without water there would be no life of any kind on the Earth, and without water readily available in adequate quantity and free of pathogenic organisms human development is tremendously hindered. Sir Harold Hartley recently listed eight 'limiting factors' which might handicap the economic progress of mankind, and at the head of his list he placed shortage of water. From the time when early man first settled by a natural spring or permanent stream, down to the modern atomic power station consuming some 3,600,000 tons of coolant a day, water has been vital.

One urgent world-wide problem which faces mankind to-day is the organization of pure water for small communities in rural areas, backward countries and under-developed localities. Although no precise figures are available, it is quite certain that millions of man-days of labour are lost annually and much distress is caused because of illness and death from water-borne diseases. This tremendous problem can only be met by the organization of pure water supplies in adequate quantity and by proper sanitary measures.

It is the aim of this forty-second monograph of the World Health Organization to provide the basic information for government officials and health administrators who face this challenge. The monograph is essentially a practical handbook for civil and sanitary engineers, medical officers of health and public health administrators, and it describes in a clear and concise manner the ways and means of organizing rural water-supply in order to satisfy basic personal hygiene. Methods of installing various types of water-supply systems from both underground and surface water sources are detailed, together with a consideration of treatment under rural conditions and problems of distribution and use. The monograph concludes with a section on the management of water-supply schemes and a lengthy list of appendixes dealing with a wide variety of topics of value to the engineer working in remote areas.

It seems fairly clear from experience already gained that in most small communities in under-developed areas more health benefits can be gained from money spent on a water-supply programme than in any other way. The supply, however, must be adequate in both quantity and quality and not prohibitive in cost if the hygienic standard of the community is to be raised to a new level. There is, in fact, a remarkable degree of correlation in many communities between standards of living and consumption of water *per caput* per day. This new monograph should help materially in raising the water consumption, hygienic conditions and standards of living of many small communities at present held back by poverty-stricken conditions, high incidence of disease and death, and lack of knowledge.

W. G. V. Balchin

REACTIVE METALS

Reactive Metals

Edited by W. R. Clough. (Metallurgical Society Conference, Vol. 2.) Pp. xiv+610. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 113*s*.

THIS book presents the papers and discussion from the third Reactive Metals Conference of the American Institute of Mechanical Engineers in 1958. We have grown accustomed to the reporting of conferences in the United States, and this one follows standard practice. There is no visible sign of any theme or thread of continuity in the papers, except the commonly accepted classification of reactive metals, which here includes the transition metals of Groups IV, V and VI *A* of the Periodic System, together with uranium. The papers are grouped under properties and applications, titanium alloys, nuclear, consolidation, powder techniques, melting and refining; physical metallurgy, temperature effects, phase relationships, interstitial effects; metal processing and fabrication. As a summary of recent American work in very specific fields, such a collection may be of interest to large research and development organizations, but is more likely to be a reference book for the library than resident on the shelves of an individual.

A light-hearted discourse characterizes some of the papers, and, as so frequently happens, the bibliography does not include appropriate European work. The odd references to British papers are occasionally obscure ones (for example, U.K. Atomic Energy Authority Technical Notes) considering that the same work has often been published in the journal of a learned society. Two contributions on vanadium alloys, by Karl F. Smith and R. J. Van Thyne, discuss the requirements of fuel cladding materials in fast fission reactors. The argument follows very closely that published in Britain some three years ago, and seems to contradict the previous American point of view expressed at the Geneva conference later in 1958.

The most interesting work described is that on titanium alloys and the physical metallurgy of molybdenum, vanadium and niobium. It is a great pity that the Americans still persist in referring to 'columbium' in spite of international agreement to the contrary. There is also a strange reference on p. 7, in the keynote address by D. J. McPherson, to the use of 'columbium' in one U.S. reactor and its planned use in one British reactor. So far as I am aware the use of niobium in the Dounreay fast reactor was first suggested in 1953 and was fixed by early 1956, some years before the Conference to which this book relates.

C. R. Tottle

PLUTONIUM AND ITS ALLOYS

Extractive and Physical Metallurgy of Plutonium and Its Alloys

Edited by W. D. Wilkinson. (Based on a Symposium held in San Francisco, California, February 16–17, 1959.) Pp. x+314. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 79*s*.

ANY information on plutonium is welcome, and the freedom of discussion noticeable since the first Geneva Conference on the Peaceful Uses of Atomic Energy has led to many more symposia of the type presented in this book.

The contents are classified as the title suggests; but an introductory first chapter summarizes, very neatly, the properties of the six allotropic forms, the necessary safety precautions in handling, and discusses the solid state of the plutonium atom.

Six papers on extraction metallurgy cover a wide field, from conversion of salts to metal to removal of fission products by liquation. One American paper reports work between 1943 and 1946, and, in contrast, a French contribution refers to 1956. Detailed results are quoted for extraction coefficients in the distribution of plutonium and impurity elements between nitrate solutions and tri-butyl phosphate. This section on extraction processes will be of value to the chemical engineer working in this field, although one imagines that perhaps some of the information is already well known to those receiving security guarded reports.

The physical metallurgy papers are extremely interesting for metallurgists. A general treatment of the alloying potential of the metal is followed by articles on plutonium alloys containing cerium and zinc. The metallographic techniques required and the transformation characteristics are also referred to with respect to the metal and its alloys. References are given at the end of each paper, and an annotated bibliography and subject-index at the end of the book.

Illustrations and diagrams are well presented, and in spite of the comparatively high price, the nature of the subject matter will ensure a demand for it. Anyone concerned with nuclear energy topics should find this a valuable source of information, additional to, and in a more manageable size, than the proceedings of the Geneva conferences. C. R. TOTTLE

INSTRUMENTATION, DATA PROCESSING AND AUTOMATIC CONTROL

Progress in Automation

Vol. 1. Edited by Dr. Andrew D. Booth. Pp. viii+231. (London: Butterworths Scientific Publications, 1960.) 42*s*.

THE editor of this volume defines automation as that field of endeavour which "seeks to duplicate the activities of living creatures, including humans, by non-living but energy consuming means". He goes on to give an excellent historical survey, beginning with the water clock of Vitruvius in 245 B.C. and including many examples of early applications of automatic control. This broad definition is inevitably followed by a wide selection of topics, and the title of the volume is singularly uninformative about their content. In fact, the ten contributors to the volume cover some aspects of British progress in instrumentation, data processing and automatic control.

Articles on instrumentation are contributed by T. B. Rowley and A. E. M. Hodgson. Both are devoted to nucleonic measurement techniques using radioactive isotopes. The first deals with thickness and level measurements and the second with fluid-density measurements, and the combination gives a clear account of these important methods.

Data reduction gives rise to the need for converters to transform the varying analogue quantities in the plant or process into digital form for use by the logger or computer. An excellent contribution by G. J. Herring reviews current practice in analogue to digital conversion and considers in detail a converter designed for use in high-speed data reduction.

The contribution on steel strip mills by G. Syke is a general review of the problems of instrumentation and control in the production of continuous strip. For the chemical industry, J. M. Keating discusses the automatic control of chemical plants and indicates the necessary properties for a digital computer used as a master controller for such a plant. The problems of data processing in an oil refinery are also considered and future developments indicated.

Automatic inspection techniques are discussed by J. A. Sargrove, who considers the possibility of performing statistical analysis on the samples tested and automatically feeding back information to the production line to correct unwanted trends and faults.

There are four articles on machine tool control which form a useful record and are in many ways complementary. K. J. Coppin describes a simple method of machine tool control designed for existing machines. The desired work dimensions are set in by an operator at the start of each traverse and positional measurement is from potentiometers geared to the lead screw. Two fully automatic numerical control systems are described in articles by D. T. N. Williamson, of Ferranti, Ltd., and F. W. Hartley, of E.M.I., Ltd. The Ferranti system uses optical diffraction gratings with moiré fringe counting to achieve positional measurement and is non-interpolating. The E.M.I. system, on the other hand, uses a continuous analogue measure of tool position and interpolates parabolically between points in the stored programme of successive tool positions. Hartley's paper also contains a comparison of several British and American systems and discusses the economics of numerical machine tool control.

H. J. Finden considers in his paper a numerical control system for a machine tool in which a linear inductosyn gives a precise analogue position measurement independent of the lead screw.

The articles are well written and authoritative, and the choice of topics gives a fair cross-section of British efforts in this vast field.

The volume fills a gap in existing literature between the specialist papers in professional journals and the more popular articles on automation. In this respect it will be of value to many engineers, research workers and administrators who require a sound account of progress in a given topic without searching the literature. It is very well produced, but further volumes may be better matched to their purpose as progress reviews if made in a less costly form.

P. H. HAMMOND

SIGNALS AND STATISTICS

Statistical Theory of Signal Detection

By Dr. Carl W. Helstrom. (International Series of Monographs on Electronics and Instrumentation, Vol. 9.) Pp. viii+364. (London and New York: Pergamon Press, 1960.) 63*s*. net.

DR. HELSTROM is primarily interested in the reception of radar signals. He formulates his problems explicitly as problems in statistical inference: to detect a signal in the presence of noise (that is, to decide whether a signal of known form, or perhaps only of known statistical properties, is present or not), to estimate parameters of the signal, such as arrival time and carrier frequency, and to resolve signals, that is, to decide which of a number of known signals are present simultaneously.

After some general material on signals, filters and noise, the author gives a clear description of the Bayes, minimax and Neyman-Pearson decision criteria. Later in the book he describes the use of ratios of maximized likelihoods, and some of the properties of Bayes and maximum likelihood estimates.

The rest of the work consists largely of a detailed application of these methods to the decision problems mentioned above, for situations of varying degrees of complexity: for example, detection when one has nuisance parameters such as signal amplitude, phase and arrival time, or when repeated observations are made on the signal. An aspect of the problem novel to many statisticians is that observations are taken in continuous time, so that the idea of 'sample size' is to some extent replaced by that of 'signal to noise ratio', and the data must be transformed canonically if one is to have an enumerable set of variates.

The solutions to many of the problems are formal, in the sense that they are given in terms of the solution or the eigen values of an untreated integral equation. The author certainly gives a more explicit treatment for several specific cases, and often provides a qualitative appreciation of the results, but it is plain that there is work to be done here. The 'mechanization' of the recommended decision and estimation procedures is touched on only lightly, although, on the other hand, the author claims no more than that he is calculating a "standard of performance against which present systems can be measured", and regarding the optimum systems as guides to design.

The literature references are, perhaps understandably, not always those that a statistician would make. In common with most communications engineers, Dr. Helstrom attributes Cramér's result concerning the spectral representation of a stationary process to Rice, while the Cramér-Rao inequality is credited to Fisher.

These are matters of detail, however, well outweighed by the book's merits, of which the main ones are its clarity, thoroughness and consistent appeal to first principles. P. Whittle

PHOTOGRAMMETRY

Photogrammetry

Basic Principles and General Survey. By Prof. Bertil Hallert. (McGraw-Hill Civil Engineering Series.) Pp. ix+340. (New York: McGraw-Hill Book Company, Inc.; London: McGraw-Hill Publishing Co., Ltd., 1960.) 85*s*. 6*d*.

THERE are very few text-books on photogrammetry in English which are sufficiently modern, or which attain a sufficiently high standard of presentation to help the student bridge the very wide mathematical and technical gap between the long-established fundamental principles and modern developments of the subject. The present book goes a long way to remedy this deficiency, and it must rank as an extremely important contribution to the teaching of photogrammetry. There is much new and thought-provoking material, especially in the appendixes (which comprise nearly one-third of the book) and in Prof. Hallert's choice and treatment of worked examples.

Earlier text-books pay some sort of lip-service to the idea of statistical treatment of photogrammetric measurements, but none has examined the theory of errors with special reference to the nature of these measurements and the most convenient methods of adjusting them. The contributions of Prof. Hallert in this field are well known, and it is not therefore surprising that one of the most important innovations of this text is a lucid "Introduction of Photogrammetric Theory of Errors" and frequent use of statistical checks in the worked examples.

The most important criticism which must be made is that there is no proper treatment of analytical aerial triangulation. Five years ago this might have been dismissed as a peculiarly British practice, developed by the Ordnance Survey for a special task. In recent years, however, the suitability of the method has been recognized in many other countries, not only for topographical mapping but also in the applications of photogrammetry to ballistic and satellite research. In this book the part devoted to aerial triangulation deals only with methods of radial triangulation and bridging with plotting machines. The reader is left with the impression that the stereocomparator is only used for terrestrial photogrammetry. The importance of the camera réseau as the only really satisfactory method of correcting film distortion is not described, despite Hallert's condemnation of the use of a register glass in aerial cameras.

Another remarkable omission is the absence of any description of the more refined methods of analogue adjustment to a block of any sort of aerial triangulation. Slotted templates are, of course, described in some detail, but there is no mention of either stereotemplates or the '*ITC*-Jerie' analogue computer. The last is surely one of the most important developments in the whole field of photogrammetry during the post-war period. D. H. Maling

A HOOKE BIBLIOGRAPHY

A Bibliography of Dr. Robert Hooke

By Sir Geoffrey Keynes. Pp. xix+115+12 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1960.) 50*s*. net.

THE recent tercentenary celebrations of the Royal Society have cast our minds back to the early years when that illustrious fellowship was enriched by the inventive genius of Robert Hooke. As curator of experiments, secretary and editor, Hooke was constantly active on the Society's behalf, and he may well have saved it from early extinction. But his colleagues failed to appreciate his true worth; he was injured by the enmity of the pre-eminent Newton, and his fame suffered a posthumous eclipse which persisted for two centuries. Only in our own day, and largely through the advocacy of Prof. E. N. da C. Andrade, has Hooke received something approaching proper recognition as a pioneer in many branches of science and as Wren's trusted associate in the immense task of rebuilding London after the Great Fire.

Hooke's few published works, now rare, afford but little idea of the immense range and fertility of his inventive capacity as it is revealed in the records of the Royal Society over many years. Much of this recorded material became generally accessible some twenty-five years ago through the publication of R. T. Gunther's volumes on Hooke in his "Early Science in Oxford". Light was cast from another angle on Hooke's enigmatic personality by the editing of his "Diaries". But the archives of the Society and other repositories preserve many still unpublished manuscripts and letters by or relating to Hooke, the location and contents of which are not generally known to students and which should be taken into account in any final assessment of the man and his age.

A concise, serviceable bibliography of all this material has now been compiled by Sir Geoffrey Keynes in fulfilment of a plan conceived many years ago in discussions with the late Prof. John Fulton of Yale. It opens with a prefatory account of Hooke's career and of the problems facing his bibliographer, passing thence to a discussion of the continuation of Bacon's

"New Atlantis", by "R. H. Esquire" and dated 1660. Sir Geoffrey inclines to the belief that this was, in fact, Hooke's first published book. Other sections deal with Hooke's early tract on capillary attraction, his controversy with Auzout, the "Micrographia" and its derivatives, the six Cutlerian Lectures, the "Philosophical Collections" which Hooke edited to fill a gap in the sequence of *Philosophical Transactions* caused by Oldenburg's death, Waller's edition of the "Posthumous Works", Hooke's contributions to the *Transactions* and to contemporary books, and, finally, the "Diaries". Following the bibliography proper are four appendixes: these comprise a summary list of Hooke's papers and letters preserved in manuscript, a list of letters from printed sources, a selection of books and articles bearing upon Hooke, and, lastly, Newton's notes on the "Micrographia" which have not been transcribed before.

The book is excellently produced, and its interest is enhanced by the inclusion of reproductions of the title-pages and of a few historic plates from Hooke's works; there are also drawings of the College of Physicians which he designed. Sir Geoffrey Keynes has fashioned a tool which will prove indispensable to students of the life and times of Newton's greatest rival.

A. ARMITAGE

AN INTERPRETER OF WHITEHEAD

Whitehead's Philosophy of Science

By Dr. Robert M. Palter. Pp. xv+248. (Chicago: University of Chicago Press; London: Cambridge University Press, 1960.) 60*s*. net.

THERE are probably several reasons why Whitehead's contributions to philosophy have suffered some neglect, and even a little discredit, with the passage of years. One is the difficulty of his language and symbolism, another his concern with metaphysics. A great mathematician—now no longer living—once told me how shocking it was to write so obscurely as "A. N. W."; yet the same authority declared—just as Whitehead did in so many words—that metaphysics must be firmly based on science for its survival; and furthermore, that it needed to be critical of itself before it applied the lash to others.

Although the present book is not quite the first and only attempt at interpreting Whitehead, it is assuredly the fullest and most understanding yet produced. If, some forty years ago, one could have had Prof. Palter's work at hand when reading "An Enquiry concerning the Principles of Natural Knowledge" and "The Concept of Nature", many hours of frustration might at least have been shortened. In a sense, the later publications were easier to grasp, because their purpose was clearer, and the author's goal more squarely in view.

As things are now, it seems likely that Whitehead's method of extensive abstraction and his philosophy of organism will prove of current interest, and these are well discussed and illustrated in the present volume. Moreover, the latter subject is set fair to offer an epistemological basis for the coming biophysics. In this context, the quotations from Whitehead, copious as they are, fit naturally into the picture, without being tedious or destructive of the author's careful exegesis. An example is the way in which Whitehead is shown to be fully aware that natural science means the observation of things as they are, and that to rely on formal mathematical concepts alone is to perpetuate the errors of the scholastics. In fact, a few lines before this remark, Whitehead states bluntly that "If there be no stuff to appear, there can be no space" ("The Principle of Relativity", p. 39). All this shows that he was no pedant with regard to natural science.

A footnote to p. 5 rescues, from rather out-of-the-way sources, Whitehead's pregnant hint to the effect that some day æsthetics will become founded on symbolic logic. There are straws in the wind that way already.

Finally comes the concept of 'fields'. At the weakest, this means "any theory involving continuous distribution in space of some physical magnitude . . .", and at the strongest, any expression of fundamental laws as partial differential equations. It could scarcely be better said, and subsumes most of the substance of the great period of æther physics.

However complex, nothing can detract from the peculiar beauty of Whitehead's prose. His preface to "The Principles of Natural Knowledge" is pathetically lovely in its restrained sense of poignant sorrow.

I was with "A. N. W." shortly before his death: the mind was clear and the memory nearly perfect, as he looked into the Great Unknown.

F. I. G. RAWLINS

THE NEW FOREST

The New Forest

By Juanita Berlin, Edwin Cohen, Dr. Gordon J. Copley, H. L. Edlin, Oliver Hook, Juliette de Baitacli Levy, F. E. W. Venning, H. Widnell, W. R. Myers, and Sir Berkeley Pigott. Pp. x+201+27 plates. (London: Galley Press, Ltd., 1960.) 30*s*. net.

IN view of the wealth of material and scholarship that could have been drawn on, as well as the publicity given to this book, one had reason to expect an authoritative work on the New Forest. Instead, we are presented with an odd and unbalanced assortment of topics that fail to fulfil the claims put forward by the chairman of the Forestry Commission in his foreword.

In an opening chapter entitled "The Background", brief references are made to Stone Age, Bronze Age and Iron Age cultures, and to some of the commoner place names, but there is no attempt to recount or explain the fascinating history of the Forest or the communities who came to settle within its precincts. On the other hand, the chapter on "The New Forest Commoners" deals adequately with the remarkable, if complicated, administration that has evolved through the centuries.

The geology is inadequately dismissed in four pages, and as the contributor admits, much of it is "very briefly and crudely summarized". The distribution of the distinctive Forest soil types is omitted altogether. The same chapter contains a much larger section entitled "Botany", but this deals almost exclusively with pure floristics, and misses completely the opportunity to elaborate the general vegetational pattern in relation to geology and topography. Much later in the book, and separated from the general botanical section, is a rather whimsical, but

nevertheless informative and readable chapter on medicinal herbs.

In the chapter on "Mammals" the part that deals with the history, distribution and hunting of deer is adequate and competent. For the remaining mammals, except the squirrels, there is virtually nothing that relates them to the New Forest as distinct from Britain as a whole. The list of mammals is accurate.

The contribution on "Birds" is awkward in style, and there is an attempt to cram too much information into too short a space—especially when four pages of the thirteen are devoted to one species and the remaining nine pages to 150 species.

One begins to appreciate the atmosphere of the Forest in the chapter on "Perambulation Today", and Edlin's contribution on "Silviculture" is clear, authoritative and interesting.

Some of the remaining chapters and appendixes could have been omitted without loss. There is a strange collection of illustrations; a few of them are well chosen, many contribute little to an appreciation of the New Forest, and quite a number are poorly reproduced. There is no index to the book.

L. E. Tavener

ADVENTURE, BEAUTY AND SCIENCE IN AFRICA

Serengeti Shall Not Die

By Dr. Bernhard and Michael Grzimek. Pp. 344 (67 plates). (London: Hamish Hamilton, Ltd., 1960.) 30*s*. net.

THIS is the book of the film. Despite the many fine illustrations, the book cannot compete with the film in showing the space of the Serengeti National Park and the beauty of its animals in motion. But the book is complementary to the film in revealing the careful preparation, the hard work and the risks of the task undertaken by Dr. Grzimek and his son, and it gives a moving insight of their relationship.

It is a true adventure story. After the success of their first film "No Room for Wild Animals", the Grzimeks offered part of its revenues for purchase of land to increase the Serengeti National Park, but were persuaded instead to study the animal populations there; that study entailed learning to fly, and that entailed getting permission from their wives.

When these difficulties had been overcome, they made the trip to Tanganyika in their small slow aeroplane, contending with weather and officialdom, gaining sidelights on the countries through which they passed; readers who knew the Sudan before independence will find the account of the Christmas party at Juba very probable and very funny.

The book digresses from the Serengeti and contains much interesting material on the history of East Africa, and of Tanganyika in particular. Some of the opinions about Africa in general may not be shared by those who have worked there; for example, a man who lives in an isolated thatched hut may take a lively interest in world affairs; when visiting a small island on Lake Victoria in 1941, I was asked, "What will happen to France after the war?" Some may doubt the claim of a chapter heading "Knowledge of Men Lessens Philanthropic Feelings, Understanding Animals Heightens Love". Does it always?

There is a sense of urgency about the book, of the futility of proclaiming Nature reserves without the staff to look after them. But there is no occasion for the fatalistic attitude "Africa is dying and will continue to die". The wild and domestic animals and the people recovered quickly from the awful suffering and death when rinderpest swept through Africa in the last century; that was one of a sequence of major catastrophes revealed by the layers of hard and soft soil in some steep river banks, evidence of alternating erosion and recovery.

Erosion in the Serengeti is not due only to the Masai cattle. In tropical countries, wherever continued trampling forms hard tracks, as on the migration routes of the wild animals, there is some erosion, though not so intense as that caused by large herds of cattle. It is stated, "A National Park must remain a piece of primordial wilderness to be effective. No men, not even native ones, should live inside the borders". But later, "During our flights Michael and I also noted the *bomas* of the Masai and counted their herds. We found only a fraction of the number usually given. Unless their numbers rise and their cattle multiply because of modern protective injections, the Masai might not make such bad neighbours of the Park after all".

That opinion is reassuring. The Grzimeks not only carefully counted the wild animals of the Serengeti and found that they amounted to less than 400,000 instead of the supposed million, they also traced their migrations; the animals which graze near Lake Victoria, both inside and outside the National Park, from July until November, are living in the Conservation Area, where the Masai have grazing rights during January–May.

The Grzimeks also studied the plants and found that much of the pasture most palatable to wild animals was growing where the Masai kept their stock. Samples of soil were taken for analysis to discover if its composition could be correlated with the distribution of the better grasses; and that also may be correlated with the intensity of grazing, for climax grasses are too tall to suit small antelopes. But just as it was necessary to make many flights to count the animals on parallel strips, so also the vegetation of the Serengeti could be accurately described only by recording the plants on a series of parallel transects across the National Park.

Such plant recording is one of the many urgent lines of research which might be done from the Michael Grzimek Memorial Laboratory at Seronera, the Park headquarters; for Michael Grzimek, twenty-four years old, was killed when a griffon vulture collided with his aeroplane. His tombstone on the edge of the Ngorogoro crater states "He gave all he possessed for the wild animals of Africa, including his life".

"Serengeti Shall Not Die" is an account of scientific work. Some of it is controversial; none of it is dull; it is enlivened by many beautiful plates in colour and in black and white. It should be widely read, and it is to be hoped that many of the readers will show their appreciation in a practical way, by sending to the Director, Tanganyika National Parks, Arusha, a contribution to the Memorial Laboratory and thus help preservation and improvement of the Serengeti National Park.

A. S. Thomas

SHORT REVIEWS

Foods and Feeding Habits of the Pedi

With Special Reference to Identification, Classification, Preparation and Nutritive Value of the Respective Foods. By Dr. P. J. Quin. Pp. xvii+278+134 plates. (Johannesburg: Witwatersrand University Press, 1959.) 70*s*.

DR. QUIN provides in this monograph an excellent summary of his work on Bantu nutrition in the Union of South Africa. Although he confines it to the Pedi tribe, most of the data are equally relevant for other Southern Bantu tribes, and social anthropologists, economists, and nutrition experts as well as agriculturists, botanists and entomologists from all parts of Africa will find it a mine of concise and accurate information on the food and feeding habits of the Southern Bantu. The early chapters deal with the plants, animals, reptiles and insects both domestic and wild which enter into Pedi diets. The reader is given not only their local Pedi, English and Afrikaans names but also their scientific names, and in many cases their nutritional composition. Where they happen to form a significant element of Pedi diet this is given in considerable detail; for example, one species of flying ant which the Pedi call dintlhwa and the entomologists *Carebara vidua* contain, when in the flying stage, 25·2 per cent crude protein in the case of the male and 7·4 per cent in the case of the female. These chapters are followed by an examination and analysis of particular Pedi dishes and the work ends with a discussion of the Pedi dietary pattern, of modern tendencies in Southern Bantu dietary habits and of Pedi health. The supporting tables, plates and drawings are first class and there is a useful bibliography.

G. I. JONES

Religion in Plato and Cicero

By John E. Rexine. Pp. vii+72. (New York: Philosophical Library, 1959.) 2.75 dollars.

THIS interesting little book bears what amounts to the *imprimatur* of Prof. A. D. Nock, from whom the author has absorbed—and made his own—much of the recent classical tradition of Harvard University. It is an excellent record. These two lawgivers, Plato the philosopher and Cicero the orator, have seldom been studied synoptically, and their aims compared. Plato is metaphysical, and important for us to-day is his attempt to set up the first system of natural theology. Cicero insists on the usefulness of the gods to the State, if they are properly handled. In any such plan, sanctions are always at hand to deal with offenders, whether poets or otherwise.

Historically, the significance for scientific thought is the clear indication that the Deity can be known from the study of natural phenomena. Later centuries were to bring mankind experience of a less optimistic kind, leading to a severe limitation of Platonic religion. In a word, Plato's conception is a preview of the *deus philosophorum* with whom the Christian God cannot be inconsistent, but who is transcendent, and to some extent 'wholly other'. With this in mind, the author's thesis is most illuminating at the present stage of epistemological development in both theology and natural science.

For such a slender volume, there is a generous bibliography, well calculated to help further reading.

The Structure of Scientific Thought

An Introduction to Philosophy of Science. By Dr. Edward H. Madden. Pp. ix+381. (London: Routledge and Kegan Paul, Ltd., 1960.) 35*s*. net.

THIS volume is curiously constructed; it is an anthology the members of which are knit together by a series of introductions to each section. Thus, the value of the whole assemblage depends as much on the quality of these prefatory remarks as it does on the choice of the contributions themselves. The author's aim is to help students to understand the way in which scientific thought has been built up, taking examples from physics, probability, biology, psychology, axiology and so on, and presenting them in their original form. There are full references and an adequate bibliography.

Maybe this method will succeed in the United States: one cannot imagine it doing so in general, if only because the selection is so arbitrary, and somewhat weighted in favour of American sources. This is not necessarily a defect, but it tends to limit the book's appeal. The style of the several introductions is rather tiresome; there is much too much "you", as if the reader needed constant prodding. But the writer's heart is in the right place, he upholds science as a truly humanistic discipline, supreme in its own domain, and never self-conscious about being merely useful or fashionable.

The format of the collection is very attractive, though the large page size, carrying double columns, seems quite needless for a work of this character, and makes it difficult to house in an ordinary bookshelf.

F. I. G. RAWLINS

No Stone Unturned

An Almanac of North American Prehistory. By Louis A. Brennan. Pp. xii+370+8 plates. (London: Victor Gollancz, Ltd., 1960.) 25*s*. net.

THIS is a book written to propagate the idea that man first reached America more than 30,000 years ago, and that his development thereafter was completely independent and owed nothing to contacts with Asia. Only with the coming of the higher civilizations of Mexico and Peru does the author allow that something "cryptically oriental" began to "hover" over them, though he will not have anything so simple as long sea-voyages to account for it, but rather a chain of vanished islands which filtered the oriental influences into an attenuated form.

Mr. Brennan is a journalist by profession and his speech agrees thereto, but he is also a keen amateur archæologist and knows the literature. He argues his case with great ingenuity, but not always with judgment. One of the weakest features of the whole thesis

is the doubtful character of the evidence for man in America at dates of the order claimed; the instances cited are well known—Santa Rosa Island, Tule Springs and Lewisville—but Mr. Brennan does not make it clear that they are very far from commanding wide acceptance as evidence of the presence of man. As to subsequent contacts, opinions differ a good deal about their extent, but he is a bold man who will have no contact at all by way of the north Pacific, either in the last stages of the Wisconsin glaciation when the Bering Straits were dry or later in boats. To deny such contacts on negative evidence in a very imperfectly explored area, when one is prepared, as the author is, to entertain the idea of a land bridge to bring the makers of Clovis points across the Atlantic to become the Solutreans, is to show a ridiculous lack of balance.

This is not an archæological text-book. Readers who have knowledge of American archæology may find parts of it stimulating and a good deal exasperating. Those who do not should take it with a large grain of salt. G. H. S. Bushnell

The Searching Mind in Medicine

By William A. R. Thomson. Pp. 187+25 plates. (London: Museum Press, Ltd., 1960.) 21*s*. net.

A SERIES of talks, by leading authorities, on the External Series of the British Broadcasting Corporation has been converted into an attractive book by William A. R. Thomson, the editor of *The Practitioner*. Because of the pace with which changes are taking place in modern medicine, however, little remains of the original articles, although Thomson acknowledges the inspiration of the broadcasters and continued help to ensure that his material is accurate and up to date.

The articles are varied and, besides the not unexpected topics of antibiotics, viruses and the effects of radiation on man, the author deals openly and factually with the biochemistry and chemotherapy of cancer. Perhaps too much is made of existing knowledge to show causal relationship between behaviour and physique, but the chapters on memory and learning, the problem of ageing, life at low temperatures and climate and working efficiency will be of interest not only to non-medical readers but also to general practitioners whose reading may have been somewhat circumscribed. The text is concise and carries an air of authority of one who has dug deep for his facts. It is perhaps a little unfortunate, therefore, that Thomson sometimes fails to apply a searching mind to his own beliefs and gets hoist with his own petard. His statement, for example, that "the exceptional handler of men—whether doctor, army officer or teacher—has a shrewd idea of what manner of man an individual is by looking at him" would be accepted by all except those who had subjected their 'shrewd ideas' to the process of statistical investigation. Kathleen M. Hawkins

Understanding Weather

By Sir Graham Sutton. (Pelican Book, No. A469.) Pp. 215+4 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1960.) 3*s*. 6*d*.

IN this welcome book the Director-General of the Meteorological Office makes no claim to have written a comprehensive account of the science of meteorology, and indeed certain aspects of the subject—like air masses and fronts, basic elements of our everyday weather experience—are rather scantily treated. He is not much concerned either with geographical influences, such as the distribution of land and sea and the great mountain ranges, on the global circulation. Also while there is an excellent chapter on micrometeorology (as might be expected), local weather is strangely neglected (although plate 3*b* refers to a "sea-breeze front" which is nowhere mentioned in the text).

These omissions accepted, here nevertheless is an authoritative and up-to-date guide to a great deal of current thinking in meteorological science. Almost half the book is devoted to an account of modern methods of forecasting. This begins with the conventional techniques of synoptic analysis and forecasting, and goes on to Sutcliffe's development theories and Rossby's long waves (for which the way has been well prepared in earlier pages); the author then proceeds to numerical forecasting, from Richardson to the electronic computer (only here does an occasional mathematical equation intrude into an otherwise descriptive treatment), and finally offers a sober assessment of the possibilities of long-range forecasting. As an exposition on a popular level of the professional meteorologist's approach to his subject, this little book is excellent value.

M. Parry

Comparative Anatomy

By Prof. William Montagna. Pp. x+397. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 48*s*. net.

THIS is a well-planned book which introduces the student to the important principles of comparative anatomy, organogenesis and embryology. The author first deals with the characteristic features of vertebrates and the development of the body plan and body tissues. Then follows a short chapter on the Chordata, including useful tables. The skin is next considered, then the endoskeleton, the muscular system, the digestive system, the circulatory system, the respiratory system, the excretory system, the reproductive system, the sense organs and the nervous system. Finally, there is a short chapter on the endocrine glands.

In most of the chapters there is a general introduction, then the development of the system is described and thereafter the comparative anatomy in amphioxus, cyclostomes, fishes, amphibians, reptiles, birds and mammals. At the end of each chapter there is a helpful summary and a short bibliography. The author has rightly emphasized embryology more than is the usual practice in a book of this kind, since developmental events give a better understanding of anatomical detail. There is also a useful glossary at the end of the book.

The book is written well, the descriptions are simple and easily understood, and there are numerous well-labelled illustrations and photomicrographs. It is indeed more difficult to write a simple account of important principles than a detailed text-book and in this the author has truly succeeded. He is to be congratulated on producing a useful, easily read, short account of comparative anatomy which should be of great value to the student. The publishers, too, are to be congratulated on their excellent production of this volume. T. Nicol

An Introduction to Embryology

By Prof. B. I. Balinsky. Pp. xiv+562. (Philadelphia and London: W. B. Saunders Company, 1960.) 54*s*.

DR. BALINSKY has produced a most valuable text-book, in which he has, in his own words, "endeavoured to present embryology as a single science, in which the descriptive morphological approach and the experimental physiological approach are integrated. . . . The subject . . . includes such topics as post-embryonic development, regeneration, metamorphosis and asexual reproduction. Lastly, I believe that embryology cannot be presented adequately without establishing some connection with genetics".

In the past few years, two or three similar attempts have been made; for example, the outstanding "Entwicklungsphysiologie" of Alfred Kühn in 1955, and the collective work "Analysis of Development" edited by Willier, Weiss and Hamburger in the same year. Balinsky's work is, in the choice of subjects, illustrative material and interpretation, much more similar to the only other one-man English book of this kind, Waddington's "Principles of Embryology" of 1956. It is somewhat surprising to find that this work, unlike the other two, is not mentioned in the text or bibliography.

In spite of its very wide field, Balinsky's book gives a quite thorough treatment of the topics selected for discussion. The material is very up-to-date, and plentiful references are given to recent contributions. The book is also well illustrated, with figures and diagrams chosen more for their relevance to recent physiological interests than to serve as mere morphological descriptions in the manner usual in the older embryological texts. The index is unfortunately rather inadequate. This is, however, a minor fault in a work which will be very useful as the most up-to-date general treatment of embryology as a unified science.

Faune de France No. 63

Coléoptères Scarabéides. Par Renaud Paulian. Deuxième édition, revue et augmentée. Pp. ii+298. (Paris: Éditions Paul Lechevalier, 1959.) 5,500 francs.

THIS second edition of the "Faune de France" volume on scarabæoid beetles has been increased in size by some 60 pages. Changes in comparison with the first edition, which was published in 1944, are almost entirely additions. These provide more detailed information on life-histories, variation, distribution and keys for the identification of larvæ, in so far as the larvæ are known. Eight new species and two new subspecies of scarabæoid beetles have been added to the list of French species since 1944, making a total of 261 species. This gives an indication of the wealth of the French fauna, for the corresponding number for the British Isles is 68.

The work contains keys which permit complete identification down to species and varieties, and each species is described in detail with a summary of its biology and distribution so far as these are known. Experience with the first edition has shown that the keys work easily and that the figures are adequate. The indexes to predators and parasites and to host plants are a useful addition.

The author has made an attempt to use the infra-specific categories in a consistent and logical manner and to this end defines species, subspecies, race, form and aberration in the preface. The use of the term 'race' is confusing and as defined here is the equivalent of ecophenotype. Aberrations are defined as accidental variations, often unique. This being so, there seems little value in giving keys to enable them to be identified. These are, however, minor defects in a work which has proved its worth.

E. B. BRITTON

Wild Animals of the British Isles

A Guide to the Mammals, Reptiles and Batrachians of Wayside and Woodland. By Dr. Maurice Burton. (The Wayside and Woodland Series.) Pp. ix+180+111 plates. (London and New York: Frederick Warne and Co., Ltd., 1960.) 17*s*. 6*d*. net.

THIS is another beautifully bound book in the "Wayside and Woodland" Series, containing 48 excellent colour plates from photographs and 63 interesting black and white illustrations. It is the usual compact size, so would be suitable for carrying in the pocket on a ramble. In all, 58 species of amphibians, reptiles and mammals (excluding marine mammals) are included, whether as rare as the red deer, as localized as the wild cat, or as common as the house-mouse. Each is dealt with simply and in a straightforward manner, some at greater length than others. The various animals are described, each under its own name, in the following sections: insect-eaters, flying mammals, gnawing animals, flesh-eaters, hoofed animals, lizards, snakes and amphibians. These sections are preceded by a helpful introduction, and there is an index at the end of the book.

This would be a most useful addition to a school library. It would be invaluable to the young naturalist as the accounts are both clear and accurate, and would greatly assist identification. Many adults would also find this a pleasing book.

B. J. G. MAITLAND

Dangerous Marine Animals

By Bruce W. Halstead. Pp. x+146. (Cambridge, Maryland: Cornell University Press; London: Putnam and Co., Ltd., 1959.) 4 dollars; 30*s*.

IN this semi-popular, well-illustrated handbook, Dr. Halstead gives an account of marine animals that bite, sting or are poisonous to eat. He states that "it is not the purpose of this manual to throw needless scares into the skin-diving populace, but rather to point out some known facts regarding dangerous marine organisms, and to show what to do about the situation, if worse comes to worse".

He describes and illustrates each organism (and where appropriate, the venomous apparatus), including also the latest information on medical aspects, treatment and prevention. He has cast his net wide, from cœlenterates to marine reptiles and seals, and his handbook will be particularly useful to the aqualung diver, the biologist and the medical practitioner as the first compact guide to the subject.

Dr. Halstead appears to have listed all the important vertebrates, but among the invertebrates many dangerous creatures remain to be generally recognized. In the cœlenterates, for example, the author identifies a total of eleven species (out of a total of 25 stingers

listed by me after considerable searching of the literature). His list ranges from such mildly irritating shore anemones as *Actinia equina* and *Anemonia sulcata* to the deadly sea wasp (*Chiropsalmus*) that can kill in 3–8 min. Moderately severe stingers, like the coral reef hydroid *Lytocarpus*, the medusæ *Chrysaora*, *Pelagia*, *Lobonema* and the *Stephanoscyphus* stage of *Nausithoë* are not mentioned.

Likewise, we lack precise information for many other invertebrate groups on how many species are potentially dangerous. This is mentioned here, not in criticism of Dr. Halstead's most useful and up-to-date synopsis, but to indicate that our knowledge in this field is far from complete. W. J. Rees

Insects and their World

By Harold Oldroyd. Pp. viii+139 (60 plates). (London: British Museum (Natural History), 1960.) 7*s*. 6*d*. net.

SO MUCH is known about the teeming millions of insects that to write about them both accurately and simply is by no means easy. Mr. Oldroyd is therefore to be congratulated on providing for the general public and for elementary students of insects a very useful introductory text. He touches lightly on their classification, structure, physiology, behaviour, adaptations and their importance to man. The style is always lucid, avoids technical jargon and is pleasantly illuminated by shafts of wit.

The only disappointment was to find in so lavishly illustrated a book that the plates had so little relation to the interesting stories told in the text. Scarcely any of the drawings or photographs show living insects in their natural environment, or attempt to illustrate points in the life-history. Many of the photographs show pinned insects, or dead ones awkwardly posed on rather unsuitable backgrounds. May we hope that in future editions some of the less-suitable photographs will be replaced by appropriate drawings? The drawings already used are good, but rather formal, however; that by Terzi of the blue-bottle makes the photograph facing it appear very crude. The figures and plates should also be numbered in a single series.

The book is well printed on glossy paper and is free from typographical errors. The very few minor errors of fact or interpretation will doubtless be corrected in the future editions which the book deserves. G. C. Varley

Advances in Pest Control Research

Vol. 3. Edited by R. L. Metcalf. Pp. vii+448. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 109*s*.

THIS, the third volume in the series "Advances in Pest Control", consists of nine articles by different authors who each examine a limited aspect of pest control research. There is a surprisingly extensive inter-relationship between individual essays which enhances their value by providing a wider view of the subject. The volume should prove to be a useful one.

Three essays written around groups of chemicals (organic halide nematocides by W. Moje, dithiocarbamate fungicides by R. A. Ludwig and G. D. Thorn, triazine herbicides by H. Gysin and E. Knüsli) differ in emphasis according to the characteristics of the chemicals, pests and crops involved and the reactions between them. The essay on translocation by J. W. Mitchell, B. C. Smale and R. L. Metcalf clearly shows the wider knowledge of plant structure and function than of the properties which determine the penetration and movement of chemicals in plants. The empirical nature of the use of mixtures of biologically active materials is illuminated by P. S. Hewlett, who discusses the varied investigations on the joint action of insecticides with balanced emphasis. The general lack of understanding of the complexities of the interaction between chemicals and organisms can again be seen in the essay on DDT-dehydrochlorinase by H. Lipke and C. W. Kearns, who barely hint at other possibilities of biological detoxication of DDT. F. P. W. Winteringham describes the labelled pool-technique as a way of searching for the effects of an interaction between chemicals and living organisms together with techniques which make the approach possible. The search for chemicals attractive to insects is reviewed by N. Green, M. Beroza and S. A. Hall, who classify attractants according to the type of response elicited (sex, food) and discuss their possibilities for controlling, or obtaining information about, insect pests. Knowledge and imagination are the bases of the procedure, described by R. C. Bushland, of controlling insects by male sterilization.

K. A. Lord

Blakeslee

The Genus *Datura*. By Aamos G. Avery, Sophie Satina and Jacob Rietsema. Pp. xli+289. (New York: The Ronald Press Company, 1959.) 8.75 dollars.

AN unfortunate title, for this is not, as one might imagine, a revision or monograph of the genus *Datura*, but rather a special kind of *Festschrift* compiled in honour of the late Dr. Albert F. Blakeslee, dealing with various aspects of the biology of a number of *Datura* species. Dr. Blakeslee devoted almost forty years to the study of the 'Jimson weed' (*Datura stramonium*) and its near allies, and this book shows just what can be accomplished by such intensive cultivation of a limited field. The results are certainly impressive, at least so far as genetical and cytological researches are concerned, and, for the taxonomist, it is especially interesting to have minute details of the mechanisms of variation explained on the whole lucidly and with some degree of consideration for those who are not professional geneticists. In this connexion the chapters on polyploidy, extra chromosomal types and gene mutations are particularly enlightening: it is surely by such studies of mechanisms rather than by controversy and hypothesis that the secrets of evolution and phylogeny will be revealed. Readers more concerned with practical problems of plant breeding will find much to interest them in the succeeding chapters on seed development, growth, processes in the embryo and seed, and barriers to crossability. The discourses on chimæras and radiation experiments should appeal equally to the theorist and practician. It is perhaps the taxonomist who fares worst in this symposium, for, making all due allowances, it cannot be pretended that the chapters on taxonomy and nomenclature are more than cursory. The section Brugmansia is almost wholly neglected, and we are not given any clear guidance as to the status of this group in relation to other species of *Datura*. The phytogeographers are not much better served; the geographical distribution of *Datura* species raises all

sorts of intriguing but unanswered queries. Are there any grounds, for example, for supposing that *D. stramonium* is indigenous in Europe, Asia or Africa ? Is *D. leichardtii*, which is seemingly so nearly related to the Mexican *D. pruinosa*, really a native of Australia ? Had a qualified taxonomist been privileged to work with Dr. Blakeslee's team, one feels that these questions and many others might have been answered. Deficiencies are almost certain to be found in such 'occasional' literature ; but at least it can be said that "The Genus Datura" will be a most valuable help in the preparation of future monographs of this very interesting genus. R. D. MEIKLE

A Book of Ferns

By Greta Stevenson. Second edition, revised and enlarged. Pp. iv+168. (Hamilton, New Zealand : Paul's Book Arcade, 1959.) 13*s*. 6*d*.

GRETA STEVENSON'S "A Book of Ferns", a revised edition of an earlier work, deals exclusively with the ferns of New Zealand. Although not so comprehensive as Crooke's edition of Dobbie's classic, it is, nevertheless, a well-prepared little guide and it is well illustrated with simple line drawings. Primarily intended for the novice, two-thirds of the recorded species are described. The nomenclature throughout is good, if conservative, although authorities for names are unfortunately omitted. Keys based on position of sorus and on habit of growth should enable the reader to determine his plant with comparative ease. One may question the statement that the "best size for a herbarium sheet is 17 in. by 11 in." since the Kew-size sheet, adopted in many herbaria, is 16½ in. by 10½ in. The use of naphthalene, recommended as an insect deterrent, has lost favour these days, being largely superseded by the more effective *para*dichlorbenzene. Nevertheless, Greta Stevenson's book can be thoroughly recommended as a competent introduction to New Zealand ferns. A good glossary, a list of Maori vernacular names and notes on cultivation complete a work which admirably fulfils its purpose. F. BALLARD

Trees and Bushes in Wood and Hedgerow

By Helge Vedel and Johan Lange. Translated by C. H. R. Hillman. Adapted by H. L. Edlin. Pp. 224. (London : Methuen and Co., Ltd., 1960.) 16*s*. net.

THE similarity between the flora of the two countries has made it possible to adapt this book, compiled by a team of Danish foresters and artists, to suit British forest flora. Its aim is to provide a practical reference book to the character and appearance of all trees and shrubs to be found in the open countryside. Specimens grown only in botanical collections have not been included. Each species has a reference number, which simplifies the linking of the various sections.

The book begins with an introduction to five keys. These keys are for the identification of branches with : (1) needle-like or scale-like leaves ; (2) opposite compound leaves ; (3) opposite simple leaves ; (4) alternate compound leaves ; and (5) alternate simple leaves.

Next there is a section of excellent coloured plates of 120 different trees and shrubs, with many subsidiary sketches to assist identification. Then follows the section describing each of the 127 species, with small diagrams to explain botanical details and places of origin. Each is very clearly written.

There are four interesting short sections, namely : "The Tree's Wood" ; "The Development of British Forests" ; "Forest Tree Breeding" ; and "Great Trees".

There are a Latin–English glossary, followed by a glossary of botanical terms and, lastly, an index.

B. J. G. MAITLAND

Taxonomy of Flowering Plants

By C. L. Porter. (Series of Biology Texts.) Pp. xii+452 (600 illustrations). (San Francisco and London : W. H. Freeman and Company, 1959.) 44*s*.

THIS is an excellently produced and efficiently written handbook of the taxonomy of flowering plants for North American students. It is not easy to explain in a clear and interesting way the complex matters involved in the principles of taxonomy and nomenclature, but this book comes close to doing so. Within its limitations—it does not pretend to be an advanced text-book, and the plants mentioned as examples or figured are mostly North American—it is hard to find any important fault. The numbers of species assigned to various families and genera seem not infrequently to be on the low side—there are surely more than 5,000 species of Gramineae, but otherwise the text seems excellent. The text-figures and photographs, 600 in all, are unusually numerous and clear and do much in helping to give this book the attractive appearance it has.

J. P. M. BRENAN

Die Cactaceae

Handbuch der Kakteenkunde. Von Curt Backeberg. Band 4 : Cereoideae (Boreocereeae). Pp. xxxi–xxxviii+1927–2630. (Jena : Gustav Fischer Verlag, 1960.) 91 D.M.

HERR BACKEBERG'S fourth volume is devoted to the sub-tribe Boreocereinae of the semi-tribe Boreocereeae of the tribe Cereae of the sub-family Cereoideae. It thus includes the treatments of such larger genera as *Echinocereus* (73 species), *Pilosocereus* (60), *Cereus* (36) and *Melocactus* (36). Many of the numerous smaller genera have been proposed by the author himself, who defends the recognition of small genera in his foreword. The high standard of the numerous illustrations is maintained. Philatelists will notice (Fig. 2450) the portrayal of *Melocactus communis* on the farthing postage stamp of the Turks and Caicos Islands.

Plant Pathology

An Advanced Treatise. Edited by J. G. Horsfall and A. E. Dimond. Vol. 2 : The Pathogen. Pp. xiv+715. (New York : Academic Press, Inc. ; London : Academic Press, Inc. (London), Ltd., 1960.) 22 dollars.

THIS is the second of three volumes intended to provide an advanced treatise on plant pathology. The first dealt with the diseased plant, and this one is concerned with what causes disease. In their prologue the editors indulge in words and definitions, and distinguish between three kinds of pathogen—animate, inanimate and viruses. They are in no doubt that insects are animate pathogens and are under the mistaken impression that insects are

'generally included in plant pathology in Europe', but, nevertheless, they wisely decide in the end to leave them with the entomologist. The opening chapter is a review of the nature, origin, and evolution of parasitism towards commensalism by specialization. Then follow two chapters on the reproduction of viruses, bacteria and fungi. The next six chapters are concerned with the nature of pathogenicity and cover the ability of the pathogen to breach the host by mechanical and chemical means, the importance of toxins, variability in the pathogen, and the inheritance of pathogenicity. There are also important contributions on spore germination and on soil pathogens in relation to the rhizosphere, but these are rather out of place and tend to break the continuity of the central theme.

About three-quarters of the text was prepared in more or less equal proportions by American and English authors. The other four contributions originated in Canada, India and New Zealand. There are comprehensive author and subject indexes and more than seventeen hundred literature references. It can be said now, without waiting for the third volume, that the editors and their advisory board have certainly achieved the task they set themselves in providing research workers and advanced students of applied biology with an exposition on plant pathology which is, in fact, unequalled in the English language.

W. C. Moore

British Pharmaceutical Codex 1959

Pp. xxix+1301. (London: The Pharmaceutical Press, 1959.) 70*s*.

"THE British Pharmacopœia" is mainly used by pharmacists. "The British Pharmaceutical Codex" is of more interest to the doctor; it tells him all he needs to know about the official drugs and their preparations, and adds a useful and authoritative summary of their actions and uses. It also gives specifications for other drugs, both old and new. The new "Codex" contains seventy new general monographs mainly dealing with drugs introduced in the past five years, and about one hundred of the old general monographs have been deleted, so that the new edition is shorter than its predecessor, which was itself shorter than the 1949 edition. This shrinkage is due to the elimination of remedies no longer used. The leech was fully described in the 1954 edition with an account of its actions and uses, and recommendations for storage; that monograph has now been eliminated, and the "Codex" has become less picturesque than it was and more like "The British Pharmacopœia"; the time will probably come when these two standard works will be amalgamated.

J. H. Gaddum

Food Poisoning, Food-borne Infection and Intoxication

Nature, History, and Causation; Measures for Prevention and Control. By Elliot B. Dewberry. Fourth edition. Pp. xvi+411+40 plates. (London: Leonard Hill (Books), Ltd., 1959.) 45*s*. net.

IT is a platitude to say that everything we eat is perishable, and it is therefore very difficult to understand why until relatively recently a large proportion of those entering the laboratories of the food industry were trained only in chemistry. Of these, some near enough to large industrial areas were able to attend classes in general bacteriology, a subject very difficult to teach except to full-time students. The remainder were forced to obtain their knowledge solely from text-books. The establishment of courses in food technology at various technical colleges has eased the situation, but the facilities are not yet adequate for the requirements of a virile industry.

First produced in 1943 at a time when the industry was desperately short of laboratory staff, Dewberry's book was a most useful source of information to those dealing with war-time problems of food handling and processing. The third edition in 1950 was still produced "in complete conformity with the authorized economy standards". The present edition, expanded by some 100 pages to include chapters on food hygiene, canned foods and their inspection, and (briefly) *Cl. welchii* food-poisoning, has changed little in quality of production. It has therefore become somewhat bulky for general use.

Although bacterial food-poisoning takes pride of place, sections are included on poisoning by metals, plants, fungi, fish and shellfish and on food allergy. For additional or confirmatory reading there are many references, making the book a most useful source of information for the food technologist and the seriously minded executive. It is, in fact, good value for money.

F. H. Banfield

Organic Reactions

Vol. 10. Edited by Roger Adams, A. H. Blatt, V. Boekelheide, Arthur C. Cope, David Y. Curtin, Frank C. McGrew and Carl Niemann. Pp. vii+563. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 96*s*. net.

THIS volume contains a treatment in the usual detail of three reactions capable of wide application in organic chemistry. The first, dealt with by S. M. Parmerter, concerns the coupling of diazonium salts with aliphatic carbon atoms. An explanation of its character is followed by discussions of its mechanism, scope and limitations, and synthetic applications; the experimental conditions and procedures are then considered; and lastly there is a tabular survey, classified in twelve sections, of the kinds of reactions in question. The treatment is limited to reactions in which the two nitrogen atoms of the diazonium salt remain in the new molecule.

The related Japp-Klingemann reaction is surveyed on similar lines by R. R. Phillips. The treatment of the third member of the triad, the celebrated Michael reaction, occupies the greater portion of the book (pp. 179–555) and affords a contribution of outstanding value: the thoroughness of this co-operative study by E. D. Bergmann, D. Ginsburg and R. Pappo, which was begun at the Weizmann Institute of Science, Rehovoth, is indicated by the accompanying list of 1,045 literature references.

At the end of this volume there are an author index and a chapter (subject) index covering Volumes 1–10 of this invaluable series.

John Read

Reports on the Progress of Applied Chemistry

Vol. 42, 1957. Pp. 910. (London: Society of Chemical Industry, 1958.) 100*s*.

THIS very valuable review has grown appreciably in size and price. The separate articles are all concisely written, and it would be difficult to say where, if at all, any limitation could be attempted. The book will mostly be of interest to industrial

concerns or research organizations, where price is not important. It contains summaries of a very large field of literature, much of which will be found only in large and specialized libraries, and maintains its high standard, the articles being by experts.

Fundamentals of Physical Chemistry

By Prof. H. D. Crockford and Prof. Samuel B. Knight. Pp. xvii+463. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 56*s*. net.

THIS book is based on an earlier one intended for pre-medical and other students with a limited knowledge of mathematics. It continues this plan, although the treatment is enlarged by additional topics, including three chapters on thermodynamics. The equations are deduced so far as possible, and special emphasis is given to units. Each chapter begins with a brief statement of its contents, and sub-headings and sections are titled, so that the reader knows just what is being discussed. Fully worked problems are given in the text and review questions and problems at the end of each chapter. Answers to problems are given. The treatment, especially in the part on electrolytes, is modern. The subjects covered are well selected, and the text is concise, carefully written, and clear, the authors having obviously taken great trouble with it. In future editions the conventions of sign of electrode potentials will doubtless be revised in accordance with recent recommendations, which will make the subject much clearer.

This is an excellent introductory book on physical chemistry which can be recommended to those teaching and learning the subject at this stage.

The Chemical Elements

By Helen Miles Davis. Second edition, revised. Pp. viii+198. (Washington, D.C.: Science Service, Inc.; New York: Ballantine Books, Inc., 1959.) 50 cents.

THIS is a very unusual and interesting little book. It was written by Helen Miles Davis, who died in 1957 when the second edition was in preparation. The revision was completed by Dr. Seaborg, the authority on transuranium elements. There is a survey of each element, including the history of its discovery, the whole based on the Periodic Table, and each group has a table of the atomic structure of the elements contained in it. Much of the information is in the actual words of the discoverers, taken from original papers, and this makes the book particularly interesting. The sources, isotopes and properties of each element are given concisely and some characteristic compounds are mentioned. There is nothing superfluous in the book, and its contents are of high standard.

Chemistry for Engineers

An Introductory Course. By Edward Cartmell. Pp. vii+172. (London: Butterworths Scientific Publications, 1959.) 25*s*.

THIS small book deals with a number of topics of interest to students of engineering which do not usually find a place in the ordinary elementary courses provided for science students. Even if engineering students attend such courses the book will provide a useful supplement to them. Previous knowledge is limited to such as would be available in schools, and the treatment is restricted to a selection of the more important applications of chemistry of interest to engineers. It includes such topics as fuels, metals and corrosion, water treatment, lubrication and nuclear power. The amount of space devoted to atomic and molecular structure and of valency bonds is rather large, but the treatment is intelligible and interesting. There is a good balance between general theory and practical applications, and the book should be very useful to lecturers called on to cater for the requirements of engineers who have only a limited time to devote to chemistry.

J. R. PARTINGTON

Water Treatment Handbook

Compiled by R. Leviel. Second English edition, revised. Pp. 561. (Suresnes (Seine): Degrement Acfi S.A., 1960. Distributed by Hugh K. Elliott, Ltd., 199 Piccadilly, London, W.1.) 60*s*. net; 8.40 dollars.

THE first English edition of this book was published in 1955, and there have been four French editions since 1950. After a section on methods of analysis of water and of materials used in water-works practice, the bulk of the work deals systematically and in considerable detail with the various processes used in treating water for domestic and industrial supply. The author is the technical manager of a French company which supplies water-works equipment, and many of the numerous photographs and diagrams refer to the products marketed by the firm. Thus, although methods of treating water do not differ widely in different countries, the present account is of particular value in describing the methods used in France.

Since the last edition, a new and useful section has been added on French legislation governing water supplies and the discharge to streams of sewage and industrial wastes, and containing also the recently published "International Standards for Drinking Water" put forward by the World Health Organization in 1958. There is a substantial section, more than 100 pages in length, of formulæ, tables of constants, and the like, which are used in the design of distribution networks and in the treatment of water by physical and chemical methods. There is also a chapter on the treatment of sewage and industrial wastes, but the standard of this, both as regards material and translation, is much below that of the rest of the book.

Atmospheric Diffusion and Air Pollution

Proceedings of a Symposium held at Oxford, August 24–29, 1958. Edited by F. N. Frenkiel and P. A. Sheppard. (Advances in Geophysics, Vol. 6.) Pp. xvii+471. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.

IN order to bring together scientists from the various fields in which atmospheric diffusion is important, an international symposium was arranged jointly by the International Union of Theoretical and Applied Mechanics and the International Union of Geodesy and Geophysics. The symposium was held at Oxford in August 1958, with Dr. F. N. Frenkiel and Prof. P. A. Sheppard as joint secretaries. Seven

sessions dealt respectively with: (1) a genera survey; (2) recent findings on atmospheric turbulence; (3) theory of turbulent diffusion; (4) diffusion of heavy or finite particles; (5) transfer through the troposphere and stratosphere; (6) effects of thermal stratification; (7) pollution patterns from point and area sources. Altogether more than forty papers dealing with different facets of the diffusion problem, and presenting the views of authors with different interests, were discussed. These papers, with notes of the ensuing discussions, are brought together in this volume; a few papers which are published elsewhere are represented by extended summaries.

This collection shows how the balance of contributions has, in recent years, swung from the experimental physicist to the theoretician. Possibly this reflects the wealth of empirical data now available. A notable feature is the increasing emphasis on the spectrum of turbulence.

This volume differs from others in the same series which contain articles summarizing selected topics. It is a collection of new results and new ideas which should do much to stimulate scientists who are interested in diffusion. The production is excellent and the editors should feel well satisfied with this final product of their labours. A. C. Best

Australian Atomic Energy Symposium, 1958

Proceedings of a Symposium on the Peaceful Uses of Atomic Energy in Australia, held in Sydney from June 2 to 6, 1958. Pp. xi+788. (Melbourne: Melbourne University Press; London: Cambridge University Press, 1960. Published on behalf of the Australian Atomic Energy Commission.) 100s. net.

AUSTRALIAN interest in the scientific and technological aspects of atomic energy was demonstrated in a symposium held in Sydney in June, 1958, under the auspices of the Australian Atomic Energy Commission. The full report of this symposium, containing 114 papers together with discussions, is now available in book form. The scope of the symposium was all-embracing and ranges from the geology of Australian uranium ores and the extraction of uranium from them, the prospects for nuclear power, descriptions of *Hifar*, the 10-MW. heavy-water-moderated research reactor of the Australian Atomic Energy Commission at Lucas Heights, cosmic radiation, the use of radioisotopes in physical and biological research, to education and controlled thermonuclear reactions.

Some of the papers were presented by overseas visitors, and these were generally of a review nature, but most were from Australian sources, the Australian Atomic Energy Commission itself, the Commonwealth Scientific and Industrial Research Organization and other Commonwealth and State Departments, universities, medical schools and industry. Some papers were of a topical nature, others described original work. The general impression is that of work of high quality and of a lively interest.

The volume contains such a wide variety of papers that it is fated to become a library reference book, but there can be no doubt that the symposium which it reports was a very successful affair. Not only did it bring together the wide range of Australian interests in the peaceful uses of atomic energy, but also it stimulated public interest, as was one of its intentions.
A. S. White

Classical Dynamics

By R. H. Atkin. Pp. ix+273. (London: William Heinemann, Ltd., 1959.) 30s. net.

WITHIN the limits imposed by the author he has produced a useful book. The concise explanations are good even though at times the reader may be dissatisfied with them and wish to learn more; this is especially true of the chapter on small oscillations. Moreover, the large number of worked examples and problems should be of value to students and teacher alike.

In the preface the author, who is now principal of Unischol Tutorial College, says: "I have written this book in the belief that it is possible to learn dynamics and answer examination questions at the same time", and later "It therefore seems sensible to present the subject by first explaining the ideas which are involved, in a suitable algebraic framework, and then illustrating the scope of their applications by solving a large number of typical problems". It is written for physicists and covers most of the classical dynamics in two and three dimensions needed by undergraduates up to, but not including, a reference to Hamilton's equations and variational methods.

Thus "Motion in a Plane" (Chapter 5, Section 3) consists of a clear one-page description of the importance of linear momentum, angular momentum and energy, and of the equations which contain them, together with five well-known examples which between them illustrate problems in trajectories, two particles, the use of conservation laws and rotating axes.

A book of this type is not a text-book but a manual, and the publishers admit this on the cover. No attempt is made to describe the principles of mechanics or to explain how these principles are used in the construction of apparatus and the description of physical phenomena. There is no suggestion that there are difficulties in understanding, for example, angular momentum and gyroscopic motion and that these difficulties have caused scientists to write monographs on these matters. So far as I can discover, modern physics is not even mentioned. In short it in no way resembles my idea of a good text-book on mechanics, either for a mathematician or for an engineer or a physicist.

I think it is fair to ask whether there is any need nowadays for text-books on dynamics except for engineers and for examinations. Since the excellent books by Lamb many more have been published, but few, if any, of them are better. Mechanics is only one of the branches of physics from which admirable problems can be drawn to illustrate the use of the differential and integral calculus. The idea that mechanics and applied mathematics are one and the same thing is Edwardian and can now be quietly forgotten. G. J. Kynch

Optics

By Dr. C. J. Smith (A Degree Physics, Part 3.) Pp. vii+736. (London: Edward Arnold (Publishers), Ltd., 1960.) 63s. net.

THIS volume continues Dr. Smith's series of books designed for students taking the B.Sc. General degree. The early chapters deal with the general properties of waves and vibrations, with the measurement of the velocity of light, and with the wave-theory and Newton's corpuscular theory. Lenses

are followed by a detailed treatment of non-paraxial rays and aberrations, and of the simpler optical instruments. The full and critical discussion of colour and colorimetry and the two chapters on interference in thin films and in thick plates are good and up to date, as chronicles of progress. But it seems strange to find, in a book of this level, accounts of line spectra and photoelectricity that do not mention quanta or photons; a brief mention of the electromagnetic theory in the last chapter so that polarization by reflexion can be explained in terms of the Fresnel equations (quoted); and nearly everything that Michelson is known for except the Michelson–Morley experiment. It is almost as if the book had been censored; in which case a titillating phrase about the special theory of relativity on p. 35 has been missed.

One must of course be reasonable. The author has had to decide where and when in this monumental series he will introduce a given topic, and its very scale must lead to an almost ruthless compartmentalizing and some very difficult decisions. One thing has to be done thoroughly at a time, and the student who has worked through the text of this volume will have gained a very thorough grounding in optics. He should certainly never find himself at sea; so that this compartment really need not have been quite so watertight.

Thermodynamics

By Gordon J. Van Wylen. Pp. xxiii+567. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 64*s*. net.

PROF. VAN WYLEN'S book is directed to the engineer, and here the comparison would probably be with Roberts and Miller, or with Zemansky. The idea of temperature and the zeroth law of thermodynamics, and the properties of pure substances, are first discussed; entropy is treated as an important and exchangeable physical property of a system; and the concept of irreversibility is thoroughly explored. Practical power and refrigeration cycles, and the operation of turbines, are explained, with many examples. The interesting thing here is the emphasis on general principles and their applications to the real world; the older outlook was perhaps centred on the ideal gas and the reversible cycle and a mathematician's entropy that started as a perfect differential and ended up as the logarithm of a probability. Some of the revered conventional textbook material cannot be found here at all, and some is mentioned only briefly; this has made for a clearer and more attractive presentation of the macroscopic point of view. G. R. NOAKES

Modern Physics

By Prof. H. A. Wilson. Fourth edition. (The Student's Physics.) Pp. xv+473. (London and Glasgow: Blackie and Son, Ltd., 1959.) 40*s*. net.

THERE must always be some doubt about the length of time for which a text-book should be kept alive. The first edition of this book was published in 1928, and it was then up to date and authoritative; now it is sadly behind the times. The author is, of course, an authority on the theoretical aspects of the physics he treats, but he does not seem to be at home in the new sections on semi-conductors (6 pp.), low-temperature physics (11 pp.), and elementary particles (2 pp.). Some of the chapters such as that on X-ray crystallography look old-fashioned, and it is surprising to find a topic such as the J phenomenon still included.

The trouble is that a text-book cannot be kept up to date merely by adding sections "here and there" (the phrase used in the dust cover); there must be pruning and re-distribution as well. The author has sadly failed to live up to the title of "Modern Physics". H. LIPSON

Methods of Experimental Physics

Vol. 1: Classical Methods. Edited by Immanuel Estermann. Pp. xii+596. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 12.80 dollars.

THE series of volumes of which this is the first covers the whole field of experimental physics, and the term "Classical Methods" is explained in the preface as meaning the kind of experiment that is associated with the conventional subdivisions of macroscopic physics. It deals with the evaluation of measurements; the definitions of fundamental units and the determination of 'best values' of the fundamental constants; the mechanics of solids, of fluids, and of vibrations; heat and thermodynamics; optics; electricity; and magnetism. The authors, while working as a team and preserving a uniformity of style, have enjoyed considerable latitude in treatment; some, as P. M. Marcus on thermodynamics, have gone fairly deeply into the underlying theory; others, as J. R. Holms and G. L. Weissler on optics, have concentrated on a full discussion of experimental details. The result is a concise summary of modern techniques, which is in many places a good deal more readable than the usual kind of reference book. It is intended for the physicist who needs a concise and critical guide on matters outside his own special field, and should prove useful for this purpose. G. R. NOAKES

Nuclear Reactor Materials

By Dr. B. R. T. Frost and Dr. W. B. Waldron. (Nuclear Engineering Monographs.) Pp. vii+79. (London: Temple Press, Ltd., 1959.) 12*s*. 6*d*. net.

THIS monograph is one of a very useful series dealing with the physics and engineering of nuclear reactors. It is intended for the use of university and technical college students, research assistants and qualified technicians who require a broad understanding of those topics of nuclear engineering outside their own particular field of study. Previous volumes in the series have dealt with basic nuclear physics, reactor theory, heat transfer, shielding, and reactor control and instrumentation. The present volume gives an excellent outline of the special physical and mechanical properties required of the structural and fuel materials used in reactors and of the recent metallurgical developments in order to provide these materials. The monograph is based on a series of lectures which was given by members of the staff of the Metallurgy Division, Atomic Energy Research Establishment, Harwell, to students in the Department of Nuclear Engineering, Queen Mary College, London, and both the authors are members of the staff of the Division.

The contents consist of six chapters and a comprehensive bibliography. In Chapter 1 the more important aspects of modern metallurgical theory are surveyed, and the common metallurgical terms are explained. Chapter 2, devoted to structural materials, deals separately with aluminium, magnesium, beryllium, iron and steel, and the refractory metals, zirconium, niobium, tantalum, vanadium and molybdenum. Subsequent chapters deal with the fuel materials (uranium, plutonium and thorium); liquid metals as coolants and as carriers for liquid–metal fuels and blankets; ceramics and metal–ceramic mixtures used as fuels, moderators, or as control and shielding materials; and the final chapter discusses the problem of corrosion of the fuel and canning materials by the various coolants. The text is adequately supplemented by tabulated data and clear line drawings. S. Weintroub

Nuclear Reactor Optimization

By P. H. Margen. (Nuclear Engineering Monographs.) Pp. x + 81. (London: Temple Press, Ltd., 1960.) 12*s*. 6*d*. net.

THE book which is under notice is intended to provide students and research assistants with a broad understanding of specific topics in this field. It competently describes a technique, based on fairly elementary formulations of the relevant theory, for varying the parameters of a given power reactor design to reach the lowest overall power cost and gives a detailed discussion of the application of this technique to a heavy-water-moderated, carbon-dioxide-cooled reactor.

Such a discussion requires a brief comment on almost all the factors which affect the design of the reactor, and the author has succeeded in providing a mass of detailed information without obscuring the main lines of the argument.

This presentation may lead the reader to conclude that effective design can therefore always be achieved by appropriate modification of the elementary mathematical procedures described in this book. In practice, validation of a particular design requires the use of markedly more sophisticated computational techniques. These provide a starting point for an optimization study and must again be used to check the optimized design if it departs appreciably from the initial concept.

In fact, a situation in which all main reactor parameters can be fixed merely by a minimization of total power cost is unusual—and the inclusion of constraints such as peak fuel centre temperature or burn-out margin is vital to the analysis. The essential role of such constraints is insufficiently emphasized in the presentation.

These criticisms do not obscure the merits of a clear presentation of an important aspect of reactor design.

J. Fell

University Physics

By Prof. F. C. Champion. Revised, one volume edition. Pp. viii+786. (London and Glasgow: Blackie and Son, Ltd., 1960.) 30*s*. net.

THIS book aims at giving what might be called basic physics—roughly the content of first- and second-year university courses—in one volume. It succeeds in this aim by sternly resisting any temptation to stray on to specialized topics, and it thus gives the impression of being rather dull. There are, however, three chapters at the end that deal with modern physics, but they do not go deeply into any aspects.

Many examples of examination questions, with answers and hints for solutions, are also included. These are not always wisely chosen; often they are purely bookwork questions which do not give the aid to students that quantitative problems would give. Moreover, the practical element sometimes seems to be lacking; in a.c. theory, for example, the emphasis—quite rightly—is on basic principles, but there should also be some attention paid to producing answers in ordinary units.

It might also be mentioned that a Cartesian convention is used for optics, in accordance with general university practice. In electricity and magnetism the C.G.S. system is used, the M.K.S. system being dismissed rather summarily.

To summarize, this is a sound book that will be useful as a reference book for students, but it is unlikely to fire them with an enthusiasm for physics.

H. Lipson

Analytical and Canonical Formalism in Physics

By Prof. André Mercier. (Series in Physics.) Pp. viii+222. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1959.) 40*s*.

LAGRANGE'S formalization of analytical dynamics by sets of differential operators applied to certain functions characterizing a dynamical system led to Hamilton's variational principle and his canonical equations. The extension of the field of application of Hamilton's principle, from classical dynamics to more general physical systems, may sometimes have seemed to be an exercise in pure mathematics, but relativity and quantum field theory have renewed the interest in structural formalism, so that it is not surprising that one of Prof. Mercier's aims is to show that much of the modern formal field theory is of pre-quantic character. The emphasis is on structure, but here and there illustrations from specific physical domains are given, and a number of problems for the reader are proposed; these are not examination-type questions, but generally ask for the completion or extension of abbreviated detail in the text. The book provides a profound investigation of the role of basic mathematical formalism in physics, from Lagrange to Dirac, and will repay those readers who are prepared to follow a closely argued mathematical essay in anatomy.

T. A. A. Broadbent

A Course in Applied Mathematics

By Prof. Derek F. Lawden. Pp. xv+655. (London: English Universities Press, Ltd., 1960.) 70*s*. net.

PROF. LAWDEN'S book is chiefly intended for students reading for Part 2 of the London General B.Sc. under the recently revised regulations. It conveniently contains all the applied mathematics required by this syllabus: Lagrange's equations, but not variational principles, in dynamics; the elements of the Faraday–Maxwell electromagnetic theory and foundations of potential theory; stress and strain and simple elastic problems; basic equations for the motion of an ideal fluid, with simple instances of irrotational flow and of vortex motion.

The text is clear and logically organized; a knowledge of vector algebra is assumed, but vectors are used sensibly and appropriately, and no attempt is made to force every argument into a vector mould. The operators 'grad', 'div' and 'curl' arise naturally in field theory, though perhaps a little more stress might have been laid on the fact that these are simply three aspects of the single Hamilton operator ∇. There is a good supply of worked examples and of exercises for the student, carefully selected from degree examinations to illustrate the principles and details of the theory.

This is a very useful text-book, and if it is a little deficient in outlook value, that may be because the author has chosen to work thoroughly in a carefully restricted domain. T. A. A. BROADBENT

How Photography Works

By Dr. H. J. Walls. Pp. 352. (London and New York: Focal Press, Ltd., 1959.) 42*s*. net.

THIS book can be strongly recommended to those making a career in the profession of photography who have already acquired some photographic knowledge. Despite some good attempts by the author to justify his claim in the preface that no scientific knowledge is assumed, it must be stated that the book would prove difficult reading for any person without a good knowledge of general science at Intermediate examination level. While not being a text-book, it would be excellent general reading for such people and, for this reason, it should also appeal to amateur photographers having a similar educational background.

After the first chapter on the formation of an image, which includes many features of lens design, there follow nine chapters on the mechanisms of the photographic process from initial exposure to the completion of processing. Two chapters deal with the subjective aspects of viewing photographs and there are also two chapters on colour photography. After each chapter good references are given for further reading, and the index has been carefully prepared.

R. B. COLLINS

Handbook of Textile Fibres

By Dr. J. Gordon Cook. Pp. xxv+422. (Watford: Merrow Publishing Co., Ltd., 1959.) 15*s*. net.

THIS book well justifies its title. It is most handy for looking up things about textile fibres in use to-day, of every kind apparently, natural and man-made, that one can think of. They comprise natural fibres, vegetable, animal and mineral; regenerated fibres of polysaccharide and protein origin; and synthetic fibres from polyamides, polyesters, polyvinyl derivatives, polyolefines, glass, ceramics, metals—there are, in fact, almost four double-column pages of them in the index. That does not mean, though, that the book is stodgy and chiefly masses of tables—far from it: also presented are the history and economics, production and processing (with special attention to dyeing), structure and properties, the behaviour of the fibre in practical use, and technical notes besides; all set out compactly and systematically yet achieving the double purpose of a reference book for the more experienced technologist and of an instructive general guide for the beginner. It is comprehensive enough as an introduction to textile fibres as a whole, and also provides comprehensive details about them as individuals. It could scarcely be more useful for its size, and is strongly recommended.

W. T. ASTBURY

Siberian Arctic

The Story of the Siberia Company. By Jonas Lied. Pp. 214+31 plates. (London: Methuen and Co., Ltd., 1960.) 30*s*. net.

THE events described in the main part of Mr. Lied's book took place during 1910–1920, though they are prefaced by an admirable *résumé* of the previous history of Siberia and followed by an account of what is known of events under Soviet rule.

In 1910 the only practical transport routes from the vast Siberian plains were along the course of the Rivers Obi and Yenisey; the Obi and its tributaries navigable for some 9,000 miles, and the Yenisey for 2,000. To the south the rivers met the Trans-Siberia Railway, a means of transport to the west, but a prohibitively expensive one for trade purposes; and to the north they flowed into the Kara Sea, a potential cheap waterway to the markets of Europe and America. The possibilities of this route had interested various merchant adventurers, but, until 1910, none of them had possessed the necessary business ability and resources to develop them. Then Alfred Derry, buyer and director of Messrs. Derry and Toms, drapers of Kensington High Street, London, caught a glimpse of the vision during visits to the annual trade fair at Nijhny Novgorod. A chance meeting with an energetic young Norwegian, Jonas Lied, followed, and early in 1912 was formed the Siberian Steamship Manufacturing and Trading Co. Ltd. Lied himself carried out all the investigations and negotiations at the Russian end, and his account of those exciting days is the best part of the book. The first successful season was in 1913 when cargoes of cement and assorted trade goods were exchanged for two camels from Turkestan, two bears, a roebuck and an assortment of more-valuable, if less-colourful, local products. Exports from Siberia included timber, flax, hemp, wheat, hides, butter and potash; imports were machinery, cement and general trade goods. The company, after initial vicissitudes, was advancing towards success when the Russian revolution put an end to its prospects, though it was a long time dying against a somewhat tedious background of internal squabbles.

L. M. FORBES

Geology of Norway

Edited by Olaf Holtedahl. Pp. xii+540, with 21 separate maps. (Oslo: Norges Geologiske Undersökelse, No. 208, 1960.) 100 Norwegian crowns.

Geology of Sweden

Description to accompany the Map of the Pre-Quaternary Rocks of Sweden. By N. H. Magnusson and others. Pp. 177, with map (1 : 1,000,000) in three sheets. (Stockholm: Sveriges Geologiska Undersökning, Ser. Ba, No. 16, 1960.) Text 15 Swedish crowns, map 45 Swedish crowns.

MODERN text-books on the geology of Norway and of Sweden have, until now, been available only in the national languages and in Russian translations; and a most welcome outcome of the twenty-first International Geological Congress in Scandinavia is the appearance of these new works in

English, compiled by the respective Geological Surveys. The text on Norway, by 21 authors, carefully summarizes the extensive literature and is particularly valuable for its well-chosen bibliographies. It is accompanied by an attractively coloured 'solid' map of the country on the scale 1 : 1,000,000, a 'drift' map (1 : 2,000,000), and nineteen other maps on various scales illustrative of classical Norwegian districts and of the economic geology. The memoir on Sweden is the work of five authors and, like the maps, relates to the solid geology only; but a comparable monograph by G. Lundqvist on the Quaternary formations (Stockholm: Sveriges Geologiska Undersökning, Ser. Ba, No. 17, 1960), with drift maps, has been published separately at the same price. All these publications will have a long life and should find a place even in the smaller geological library.

C. F. Davidson

The Early Lectures of Ralph Waldo Emerson

Vol. 1: 1833–1836. Edited by Stephen E. Whicher and Robert E. Spiller. Pp. xxvii+545. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1959.) 100*s*. net.

SOON after his resignation from the pastorate of the Unitarian Church at Boston, Emerson considerably extended the cultural activities of the district by a series of lectures for which he has become well known. They were particularly concerned with the elucidation of natural phenomena, the biographies of great men and literature. To each lecture Emerson brought the fruits of keen observation, wide reading and powerful thinking. The result was a many-sided contribution to knowledge and philosophy, which, in this new work, emerges with a freshness which is remarkable for material published one hundred and twenty years ago. Reasons for the study of natural history, man's place in the universe, Emerson's keen analysis of the place of water in Nature; notes on his wanderings in Italy; the life-histories of Luther, Michel Angelo Buonarroti, Mellor, George Fox, Burke; an account of the traits of the "English National Genius", all reveal Emerson as a man whose contributions to cultural life were deep and wide-ranging.

Profs. Whicher and Spiller have worked long and patiently to produce the lectures in a form complete with extensive technical and informative notes which make them invaluable for reading material originally intended for oral communication.

Subject Catalogues

Headings and Structure. Pp. 186. (London: The Library Association, 1960.) 22*s*.; 3.30 dollars.

IN this book Mr. Coates, who has been in charge of the cataloguing side of the "British National Bibliography" almost from its inception, deals with some of the problems which arise when an attempt is made to build subject catalogues, classified or alphabetical, on some systematic basis. It is concerned essentially with first principles, but assumes some background knowledge such as can be acquired from a standard text-book on cataloguing, and it not only directs attention to the shortcomings of some of the classification schemes in general use but also provides a timely warning against excessive reliance on mechanical information retrieval, and a reminder that a machine cannot produce more than has originally been put into its construction. After describing C. A. Catto's contribution to the systematization of alphabetical subject indexing, Mr. Coates reviews the subsequent contributions to subject-heading theory of Keiser, Ranganathan and Faradane. Then, after a chapter on the dictionary catalogue since Cutler, he examines the contribution of classification and outlines the application of Ranganathan's chain procedure to the colon classification and to the decimal classification. Finally, after considering the use of group arrangement in the subject index, Mr. Coates discusses the subject catalogue from the point of view of the user. Comprehensive references to the literature enhance the value of a scholarly book not merely to practising cataloguers and to students of cataloguing but also to those concerned with the further research in classification which is still required.

Britain's Scientific and Technological Manpower

By George Louis Payne. (Prepared for the President's Committee on Scientists and Engineers.) Pp. xiii+466. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1960.) 45*s*. net.

THIS book is based on a review of British official documents dealing with technological man-power undertaken at the request of President Eisenhower's Committee on Scientists and Engineers. Essentially it is an expansion of an annotated bibliography of official documents and publications concerning British scientific and technological man-power and education, and this literature is covered comprehensively up to the time of Lord Hailsham's appointment as Minister for Science. With the exception of the Crowther Report and the second White Paper on Industrial Research and Development Expenditure, 1958, there is very little of importance that is not covered, and the value of the survey both to the American and to the British reader is enhanced by the effort made to present where possible comparable American statistics.

The scope of the survey and the broad view taken are sufficiently indicated by the chapter headings. Introductory notes on terminology, etc., and a chapter on the problem and its background are followed by chapters on technical man-power and its employment in 1956 and on current and expected demand for scientists and engineers. Three chapters follow on the secondary schools, the universities and on non-university channels to a technical education. Next come two chapters on the expansion of educational facilities and on the expansion of educational opportunities, the latter dealing with scholarships, student release by employers and the like; and finally two chapters on research and development and on technological expansion and the social scene. There are some supplementary notes on professional terms and institutions and on the universities in an appendix, and also some notes on American man-power statistics.

What critical comment the book contains is mainly in the last chapter; but the value of the book lies in its comprehensive presentation of published information on the scientific and technological man-power situation in Great Britain since the Second World War in all its varied aspects. It is an admirable reference work, and British as well as American readers should be grateful for the thoroughness with which the information has been collected and the clarity of its presentation.

R. Brightman

(*Continued from page* 806)

a consistent direction of magnetization up to 4° away from the magnetizing field direction. This natural anisotropy precludes the use of separate specimens for non-pressure and pressure experiments.

This factor, together with the grain-size factor, may have contributed to the experimental results which led Stott and Stacey to suggest that the effect of pressure on a rock acquiring a thermoremanent moment was completely reversible.

It is hoped to publish in the near future a fuller description of the experiments and results of this investigation, which has been carried out with the supervision and encouragement of Prof. J. M. Bruckshaw.

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METEOROLOGY

Autumn Temperatures in the Red Sea Hills

During the autumn vacation, we made geomorphological and biological surveys in the Red Sea hills and coastal plain north of Port Sudan. Details of these will be published later. While trekking among uncharted jebels in the area 36·50° E., 21·00° N., high surface temperatures were recorded, especially on wind-blown sand. For example, on September 24, 1960, at 1300h. local time, when the air temperature varied between 40·5 and 43·5° C. (105–110° F.) the surface sand temperature was 83·5° C. (182·5° F.) as measured with an electrical resistance thermometer employing thermistors[1]. The only animal to be seen was a solitary grasshopper. Four hours later, when the temperature had fallen to 32·0° C. (90·0° F.), the sand temperature had dropped 45·5° C. to 38·0° C. (100·5° F.) and some ants were crawling over it.

These results give some idea not only of the enormous temperature fluctuations that occur in desert regions[2,3] but also of the high ground temperatures that are by no means unusual in the Sudan even quite late in the year. They compare with 84° C. (183° F.) recorded on the Loango Coast close to the equator, 78° C. (172° F.) on a sand dune in the Sahara[2], a black bulb temperature and sand surface temperature of 58° C. (136° F.) near Cairo[3]. Very much higher temperatures were obtained in fine wind-blown sand, which must have high insulating properties, than on mixed or coarse sands, gravel or rock surfaces.

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RADIATION CHEMISTRY

Kinetics of Radiation-induced Chemical Reactions

The development of linear accelerators which can produce electron pulses a few μsec. long with a peak current of several hundred m.amp. and an energy of several MeV. has made possible the study of chemical reactions by techniques similar to those used in flash photolysis. A single pulse from this type of machine will deliver a dose of the order of several thousand rads to a few ml. of liquid and should in many cases produce a chemical change large enough to be easily detectable by optical absorption with a time resolution as low as 0·1 μsec. Experiments of this kind, in which the production of the benzyl radical from benzyl compounds in organic solutions was investigated, have already been described by McCarthy and MacLachlan[1]. I am doing some similar work on various aqueous solutions, and this communication briefly describes my apparatus and some of the preliminary results obtained with it.

Irradiations are carried out at the Linear Accelerator Facility in the Scientific Apparatus Department, Associated Electrical Industries, Ltd., Manchester, which has available a machine producing 2 μsec. pulses of 4-MeV. electrons[2]. The irradiation cell consists of a thin-walled 'Pyrex' tube 20 mm. diameter and 50 mm. long, closed with quartz end-windows. The electron beam enters through the side of this tube, and a beam of light from a high-pressure mercury lamp passes along its axis. The optical system is arranged to focus the transmitted light on to the entrance slit of a monochromator and then on to a photocell. The photocell output passes through an amplifier with a rise time of about 0·1 μsec. and is applied to the vertical deflexion plates of a cathode-ray oscilloscope the horizontal sweep of which is arranged to start a few μsec. before the electron pulse. In this way traces are obtained showing the time variation in optical absorption of the liquid in the irradiation cell at any chosen wave-length. With the monochromator entrance slit closed a spurious signal is obtained and shows as 'noise' on the oscilloscope screen. This noise lasts for 2 μsec., and is caused by electrical interference produced at the same time as the pulse. Its amplitude is equivalent to a few per cent of the full signal obtained from the light source, and this limits the change in light intensity which can be detected during the pulse to a few per cent. This relatively low level of interference has been achieved by suitable electrical shielding and also by locating the monochromator outside the irradiation area to eliminate gamma-ray effects on the photocell and amplifier. Light is transmitted to the monochromator via an optical system of high aperture with a path-length of about 10 m. Traces obtained with the light source off and the monochromator slit open show an emission of light from the solution caused by the Čerenkov effect. The amplitude of this emission is fairly constant for 2 μsec., and the rise and fall times are a few tenths μsec. The optical system was designed to reduce the quantity of this light reaching the photocell to a minimum, and in practice the amount received is of the order of 10 per cent of the light from the lamp. The true absorption of a solution during the pulse is found by comparing traces made with the lamp on and off. The effects of Čerenkov light and electrical interference become

negligible a few tenths μsec. after the pulse, and from this time onward it is possible to detect changes in light intensity of about 0·1 per cent. The lamp output stays constant to better than this for periods of several hundred μsec., and changes in its output only become a limiting factor over longer intervals. Fig. 1 illustrates the performance of the apparatus at high sweep speed and high sensitivity. It was taken at 3100 Å. with once-distilled water containing dissolved air and shows an absorption after the pulse which decays with a short time constant, followed by a longer one. During the pulse the spot was deflected off the screen by the signal from the Čerenkov light. The amplitude of this deflexion was smaller with the lamp on, thus showing the presence of absorption during the pulse.

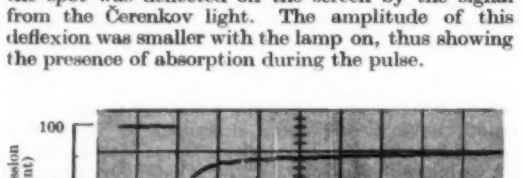

Fig. 1. Optical transmission of water at 3100 Å. ($\Delta\lambda$ 100 Å.) after a 2-μsec. electron pulse

With many solutions, permanent changes in optical absorption are produced by radiation because of the formation of stable products. I have examined the rate at which these changes occur in 5×10^{-5} molar ceric sulphate (in normal sulphuric acid) and also in three different strengths of ferrous ammonium sulphate (in 0·8 normal sulphuric acid containing 10^{-3} molar sodium chloride). Ceric sulphate absorbs light at 3350 Å. and is reduced to the non-absorbing cerous form by radiation. After a single electron-pulse the optical transmission at this wave-length was found to increase with a half-time of approximately 100 μsec. towards a new steady value. Ferrous ammonium sulphate, on the other hand, is transparent in the ultra-violet and is oxidized by radiation to the ferric form which has a broad absorption band with a maximum at 3100 Å. The optical transmission at 3150 Å., after a single electron pulse, was found to decrease towards a new steady value at a rate dependent on the initial concentration of ferrous ion. Fig. 2 shows a trace obtained with a 10^{-3} molar solution. The small dot in the top left-hand corner is the transmission immediately before the pulse and the steady decrease to a nearly constant value of about 85 per cent at 5 msec. is attributed to the production of ferric ion. The sharp transient just after the pulse was also found in sulphuric acid and is

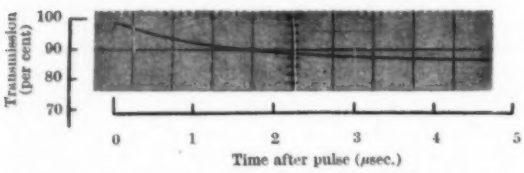

Fig. 2. Optical transmission of ferrous ammonium sulphate solution at 3150 Å. ($\Delta\lambda$ 100 Å.) after a 2-μsec. electron pulse. 10^{-3} molar ferrous solution, 10^{-3} molar sodium chloride, 0·8 normal sulphuric acid

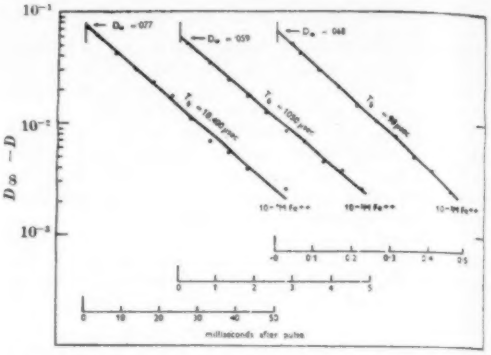

Fig. 3. Rate of appearance of ferric ion in ferrous ammonium sulphate solution after a 2-μsec. electron pulse. D, Optical density at 3150 Å.; D_∞, final steady value of density

thus not likely to be directly concerned with the ferrous–ferric reaction. The optical density D of the solution at any time after the pulse should be proportional to the amount of ferric ion present at that time and can be calculated from curves of this type. D approaches exponentially towards a final steady value D_∞ and in Fig. 3 $D_\infty - D$ is plotted as a function of time for three different concentrations of ferrous ion. The slight variation in D_∞ for the three curves is probably due to the variation of dose among pulses. The half-times ($T_{1/2}$) are inversely proportional to the concentration, and the values obtained indicate that the probability of oxidation of a ferrous ion by a radical is of the order of 10^{-5} per collision. The exponential build-up of ferric ion shown here is perhaps unexpected in view of the complicated mechanism usually postulated for this reaction[3]. However, my results do not at present exclude components with much longer half-times.

These experiments are being continued, and the kinetics of a variety of radiation-induced chemical reactions will be studied in detail. I wish to thank Associated Electrical Industries and the staff of their Irradiation Facility and also the staff of the Biochemistry Department of the Christie Hospital and Holt Radium Institute for their co-operation in this work.

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Reversible Behaviour of the Ultra-violet Irradiated Deoxyribonucleic Acid and its Apurinic Acid

The present communication reports changes produced by ultra-violet irradiation in thymidylic acid (*A*), deoxycytidylic acid (*B*), apurinic acid (*C*), deoxyribonucleic acid (*D*) and a 1 : 1 mixture of *A* and *B*, and also the reversibility of these changes in *C* and *D*. The conditions of the irradiation are described in a previous paper[1]. Apurinic acid was prepared according to the method of Tamm, Hoder

Table 1

Optical density decrease (min.)	*A*	*B*	*A* + *B*	*C*	*D*	2 × *D*
0–5	0·034	0·071	0·058	0·235	0·097	0·194
5–10	0·024	0·035	0·023	0·079	0·049	0·098
10–15	0·008	0·019	0·011	0·050	0·022	0·044
15–20	0·008	0·006	0·017	0·024	0·014	0·028
Total decrease	0·083	0·131	0·109	0·388	0·182	0·364

and Chargaff[2]. The concentration of the solutions was such that at *p*H 7 (phosphate buffer) the optical density readings at the maxima were 1.000 ± 2 per cent. The irradiation time was 20 min. for each solution, and the decrease of optical density at 260 mμ was recorded at 5 min. intervals, as shown in Table 1.

These results indicate that the decrease in optical density of the mixture of the two nucleotides (thymidylic and deoxycytidylic acids) is approximately equal to half the sum of the two nucleotides irradiated individually (½ thymidylic acid + ½ deoxycytidylic acid). However, when these two acids together exist in polymeric form, that is, apurinic acid, the decrease in optical density is more than three times that of the monomeric mixture, apurinic acid > 3 (thymidylic plus deoxycytidylic acids). I suggest that this discrepancy may be due to the unique photochemical behaviour of thymine

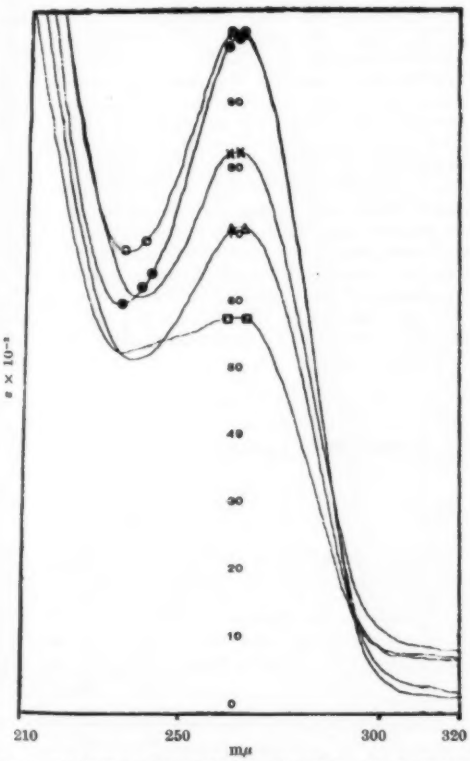

Fig. 1. Irradiation and reconstitution of apurinic acid. ○, Heated before irradiation (standard); ●, before irradiation (standard); ×, heated (6 hr.) after irradiation; △, standing (8 hr.) after irradiation; □, 20 min. irradiation

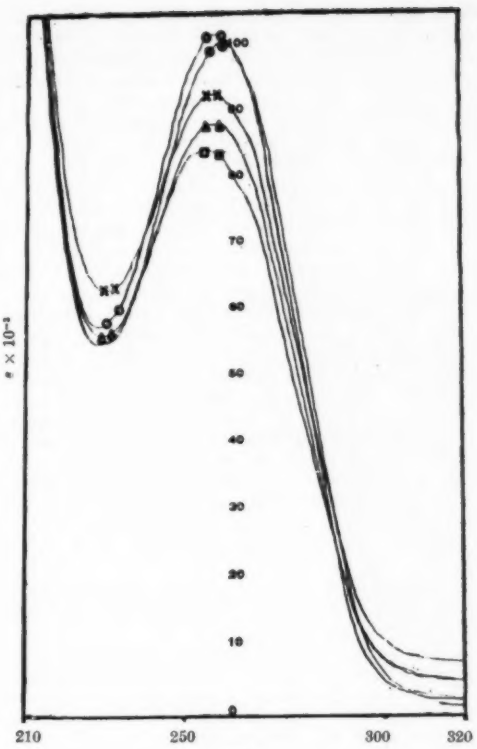

Fig. 2. Irradiation and reconstitution of deoxyribonucleic acid. ○, Heated before irradiation (standard); ●, before irradiation (standard); ×, heated (135 min.) after irradiation; △, standing (180 min.) after irradiation; □, 20 min. irradiation

derivatives[3]. Thus, I have pointed out that in polymeric nucleic acid, an unstable and reversible intermediate, 6-hydroxyhydrothymine derivative, could be formed and thus given an apparent decrease in optical density at 260 mμ. In the monomeric form (that is, thymidylic acid), the unstable intermediate would revert to the starting material during irradiation, while the slow decrease of optical density at 260 mμ would result only from degradation of this intermediate. If the above assumption is correct, the decrease of optical density of the polymer is therefore entirely owing to the irradiation effect on the two pyrimidine bases. Since purine bases are unaffected under these irradiation conditions[4], the decrease of optical density for deoxyribonucleic acid, containing about 50 per cent purines, should be half that for apurinic acid. Therefore, if the observed decrease for deoxyribonucleic acid is doubled it should equal that of apurinic acid, which is a purine-free pyrimidine nucleotide polymer. The experimental data support this hypothesis[5].

The reversibility of irradiated deoxyribonucleic acid and apurinic acid as indicated by ultra-violet spectra was observed by treatment with heat (70°), acid (*p*H ~ 2) or acid and heat and also by standing at room temperature. The spontaneous reconstitution is probably due to the reverse isomerization of irradiated deoxycytidylic acid units to the original[6]. The acid or heat reconstitution probably results from

dehydration of 6-hydroxyhydrothymidylic acid units[3]. The increase in optical density in the spontaneous reconstitution of deoxyribonucleic acid reached 0·005 as its maximum value on standing about 3 hr. For heat reconstitution, the value reached 0·092. When compared with the standard curve (heat before irradiation), the portion that is reconstituted is about 50 per cent. In the case of apurinic acid spontaneous reconstitution reached 0·118 in 8 hr. and heat reconstitution reached 0·240 (ref. 7). This is about 60 per cent reconstitution. In acid or acid and heat reconstitution the values were somewhat lower and the absorption maximum shifted to 262 mμ in both cases.

The irradiation conditions that I used were based on our findings in cytosine derivatives. In deoxyribonucleic acid, the cytosine derivative is deoxycytidylic acid and on irradiation the spontaneously reversible step for the concentration used was completed in about 20 min. This irradiation time was chosen as a standard because it was observed that at the end of 20 min. irradiation time the ultraviolet spectrum started to deviate from the isosbestic point—the criterion for the first reversible step[6]. The total energy input, or number of Einsteins absorbed in solution, was $1{\cdot}88 \times 10^{-5}$ Ein./c.c. in a 20 min. period[8].

Experiments are being continued in the hope that future work will shed some light on the biological aspects of the problem.

R. Beukers, J. Ijlstra and W. Berends[9] have just published their findings on the ultra-violet irradiation of deoxyribonucleic acid. These findings were based on their previous observations[10] on the irradiation of thymine in the frozen state. I would like to report that the irradiation of thymine and 1,3-dimethylthymine in the frozen state resulted in the formation of dimers. These dimers, determined by elementary analyses, molecular weight, ultra-violet spectra and infra-red spectra, were stable in acid, base and heat. However, in solution they would revert to the original compound when irradiated with 2537 Å. light, but are stable with 3600 Å. or light of longer wave-length. The identification of these dimeric products is being pursued in this Laboratory.

I am grateful to M. Mouyos for technical assistance.

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CHEMISTRY

Acidic Dissociation Constants of Alcoholic Hydroxyls of Hydroxycarboxylic Acids: Tartaric Acid

The hydroxycarboxylic acids form very stable complexes with metal ions. In alkaline solution, both the carboxylic and the alcoholic hydroxyl groups take part in complex formation. For the calculation of stability constants of complexes it is necessary to know the acidic dissociation constants of both groups. Since the alcoholic hydroxyls are very weakly acidic and the molecule contains relatively easily dissociable group(s) also, it is not possible to determine the dissociation constants by the usual methods. For mandelic acid the value of the dissociation constant of alcoholic hydroxyl can be calculated from the change of absorbancy at 244 mμ produced by sodium hydroxide[1]. However, in general the hydroxycarboxylic acids do not absorb even in far ultra-violet. The acidic dissociation constants of optically active substances may be estimated from the change of rotatory power produced by alkali hydroxide. The present communication deals with tartaric acid.

The rotatory power of tartaric acid first increases with increasing *p*H and reaches a limiting value about *p*H 7 (ref. 2). This increase can be attributed to the gradual ionization of the carboxylic groups. Above *p*H 13 the rotatory power decreases on further increasing the concentration of alkali. Fig. 1 shows the change of the optical rotatory power as a function of *p*H at Na_D. We used the *p*H values determined by Schwarzenbach and Sulzberger[2] instead of the concentrations of sodium or potassium hydroxide. It can be seen that in solutions containing sodium hydroxide, the direction of rotation changes at *p*H 15·76 (7·95 *M*/litre sodium hydroxide). The rotatory power also decreases in solutions which contain potassium hydroxide, but the direction of rotation does not change. However, at shorter wave-lengths the optical rotatory dispersion curves were determined between 260 and 583·9 mμ—the change of direction of rotation also takes place in the presence of potassium hydroxide. For example, at 300 mμ the rotation is zero in 9·2 *M* potassium hydroxide (*p*H 16·9) or in 4·9 *M* sodium hydroxide (*p*H 15·1).

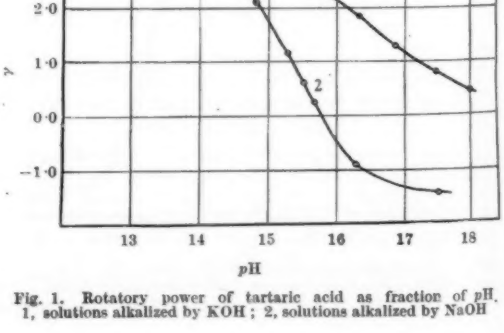

Fig. 1. Rotatory power of tartaric acid as fraction of *p*H. 1, solutions alkalized by KOH; 2, solutions alkalized by NaOH

The main reason for the decrease of rotatory power produced by increase of concentration of alkali is the gradual ionization of alcoholic hydroxyls. The differences accompanying the use of potassium hydroxide and sodium hydroxide for alkalization can be attributed to (i) secondary equilibria, and (ii) the different deformability of sodium and potassium ions. These latter effects were not taken into consideration in making the calculation. The acidic dissociation constants were estimated by Stearn and Wheland's method[4] modified by us. The acidic dissociation constants were defined by the following expressions:

$$K_3 = \frac{[TH^{3-}][H^+]}{[TH_2^{2-}]}\ ;\ K_4 = \frac{[T^{4-}][H^+]}{[TH^{3-}]}$$

Using these expressions, we find that the dissociation constants determined in solution treated with potassium hydroxide are $K_3 = 1{\cdot}13 \times 10^{-14}$ and $K_4 = 2{\cdot}54 \times 10^{-16}$; for solutions treated with sodium hydroxide, $K_3 = 1{\cdot}45 \times 10^{-14}$ and $K_4 = 3{\cdot}23 \times 10^{-16}$.

Details of the experimental work and the method of calculation will be published in *Acta Chim. Hung.*

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Theoretical Basis for Kinetic Effects in Gas-Solid Chromatography

Lateral diffusion in the gas phase as well as sorption–desorption kinetics may both influence the plate height of gas-solid chromatography. While the complicated nature and alignment of adsorbing surfaces in a column cannot be fully described mathematically, a model is presented here which allows for the fundamental diffusion and reaction processes of gas-solid chromatography. The theory is written in a general form which can be readily extended to more complex phenomena. The adsorption isotherm is assumed linear, a condition recently made practical by highly sensitive detectors.

The fundamental equation for non-equilibrium (kinetic) effects in chromatography is[1-3]:

$$s_i = (v_i - \bar{u})\ \partial m_i^*/\partial z \qquad (1)$$

where s_i is the rate of accumulation due to kinetic effects of solute in the ith form, v_i is the downstream velocity in the ith form, $\bar{u}$ is the average zone velocity, m_i^* is the equilibrium concentration expressed in the appropriate units, and z is the distance. If $i = 1$ represents the gas (fluid) phase, then we may write[3]:

$$s_1 = m_1^* D_1 \nabla^2 \varepsilon_1 \qquad (2)$$

where D_1 is the diffusion coefficient of solute in the gas and ε_1 is the equilibrium departure term for the gas. The surface, $i = 2$, accumulates solute on a unit area at the rate[3], $s_2 = -k_{21}\, m_2^*\, [\varepsilon_2 - (\varepsilon_1)_{\text{interface}}]$, where k_{21} is the first-order rate constant for desorption from the surface. If the sorption–desorption kinetics are very rapid, the term in square brackets equals zero, and the equality $\varepsilon_2 = (\varepsilon_1)_{\text{interface}}$, representing interfacial equilibrium, is a boundary condition[3] on ε_1. In this well-known case, diffusion, only, controls the non-equilibrium. In the general case, however, the above equation for s_2 becomes a boundary condition on ε_1. Using equation (1) in which $v_2 = 0$ (because the surface is stationary), this condition becomes:

$$-Rv\ \partial \ln c/\partial z = -k_{21}\,[\varepsilon_2 - (\varepsilon_1)_{\text{interface}}] \qquad (3)$$

where v is the average gas velocity, R is the ratio $\bar{u}/v$, and c is the total amount of solute in a unit volume of the chromatogram. The latter may be represented by $c = m_1^* A_1 + m_2^* S_2$, where m_1^* is the equilibrium concentration of solute in the gas, A_1 is the fractional volume of gas, m_2^* is the equilibrium amount of solute per unit area of surface, and S_2 the surface area in a unit volume. The value of R in terms of these quantities is $R = c_1^*/(c_1^* + c_2^*) = m_1^* A_1/(m_1^* A_1 + m_2^* S_2)$.

If more than one surface is involved (such as with mixed adsorbents or adsorption at a gas-liquid interface), additional surface elements, S_i, must be introduced and treated in an equivalent way. Complications caused by non-uniform surfaces, etc., have been discussed[2] in a manner readily applicable to the present case.

The elimination of s_1 between equations (1) and (2) yields the following general differential equation from which ε_1 is to be obtained:

$$\nabla^2 \varepsilon_1 = \frac{(1-R)\ v_1}{D_1}\ \frac{\partial \ln c}{\partial z} \qquad (4)$$

A special case is considered here in which parabolic flow occurring between flat plates a distance $2d_1$ apart represents the interstitial flow. The future improvement of this model to represent more accurately the support lattice should permit a significant advance in the theoretical calculation of chromatographic parameters.

Equation (4) is integrated using $v_1 = (3v/2)(1 - x^2/d_1^2)$, where x is the distance from the centre of the channel. Using equation (3) in addition to type 1 and type 5 boundary conditions from reference 3, ε_1 is found to be:

$$\varepsilon_1 = v\ \frac{\partial \ln c}{\partial z}\left[\frac{-R(1-R)}{k_{21}} - \frac{x^4}{8D_1 d_1^2} + \frac{x^2}{2D_1}\left(\frac{3}{2} - R\right) - \frac{d_1^2}{120D_1}\,(40R^2 - 108R + 75)\right] \qquad (5)$$

This expression is identical to the one representing ε_1 when equilibrium is found at the interface, except that the term containing k_{21} does not appear in the latter. The contribution of the preceding non-equilibrium to the plate height is found in the usual way as:

$$H_c = \frac{2R(1-R)v}{k_{21}} + \frac{2}{3}\left(R^2 - \frac{12}{5}\,R + \frac{51}{35}\right) v\,\frac{d_1^2}{D_1} \qquad (6)$$

Each term in this expression has been obtained individually assuming only one process to be rate controlling. The general conditions under which rate effects are additive are, however, not entirely obvious. The fact that they are not always additive has been shown using a specific model for partition chromatography[3].

While equation (6) is expected to hold at most velocities, it probably fails at higher velocities. This is the result of the interaction of lateral diffusion in the gas phase with eddy diffusion[3,4]. The latter involves shuttling molecules back and forth from rapid to slow streamlines, an effect that acts essentially to increase the lateral diffusion coefficient, D_1. This additional lateral diffusion increases in proportion to flow velocity, and is thus negligible at low velocities.

Equation (6), along with necessary extensions to the present model, should be useful in suggesting ways of changing channel size, temperature, surface area, and other surface properties in a manner that is beneficial to the separability of component zones.

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Dipole Moment Data and Hyperconjugation

It is being increasingly recognized[1] that the evidence for hyperconjugation from dipole moment data needs to be re-interpreted. Since the electronegativity of an sp or sp^3 carbon differs from that of an sp^2 carbon, the primary moments of the C(sp)—C(sp^3) and C(sp^2)—C(sp^3) bonds are not zero, and the dipole moments of molecules such as toluene, methylacetylene, etc., may arise solely from this effect.

Recently I have published a method for the calculation of bond moments based on the principle of electronegativity equalization[2], and I have now applied it to many molecules, including toluene, propylene, and butene-1. In these molecules, the atomic and homopolar dipoles cancel each other and the total moments should be given by the resultant of the vectorial sum of the primary bond moments.

From the data by Pritchard and Skinner[3], the electronegativities of sp^3 carbon and sp^2 carbon are 2·63 and 2·88, respectively. Using the screening-constants given by Kohlrausch[4], we can calculate[2] the value of the charge transferred in a C(sp^2)—C(sp^3) bond: $q = 0{\cdot}049$ e.u. Table 1 shows that the calculated primary moments of toluene, propylene, and butene-1, given by the product eqR_0 (column 4), agree extremely well with the experimental values for the dipole moments.

Table 1

Molecule	q (e.u.)	R_0 (Å.)	eqR_0 (D.)	$\mu_{exp.}$ (D.)
CH_3—C_6H_5	0·049	1·52	0·357	0·36 ± 0·02
CH_3—CH=CH_2	0·049	1·53	0·359	0·35 ± 0·01
CH_3.CH_2—CH=CH_2	0·049	1·54	0·362	0·38 − 0·30

Bond distances from "Tables of Interatomic Distances", Special Publication No. 11, Chemical Society (London, 1958).
Dipole moments from Mariott, A. A., and Buckley, F., "Table of Dielectric Constants and Dipole Moments of Substances in the Gaseous State", Nat. Bur. Stand. Circ. No. 537 (Washington, D.C., 1953).

These results can be valid only if the opposed C(sp^2)—H and C(sp^3)—H bond moments are equal. Now, the calculated C(sp^2)—H bond moment in ethylene is 0·40 D., and the calculated C(sp^3)—H bond moment in methane is 0·21 D., but the positive charge in the sp^3 carbon of the molecules under consideration (due to charge transfer to the sp^2 carbon) increases the C(sp^3)—H bond moment considerably; an iterative calculation shows that the two types of C—H bond moments cannot differ by more than 0·05 D.

It seems that the dipole moment evidence for hyperconjugation is not valid, although, since the bond moment is a ground-state property, hyperconjugation may exist in excited states and accordingly be important for the interpretation of the spectra and reactivity of molecules.

A detailed account of this work is to be submitted elsewhere.

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Reaction of Aromatic Compounds with a Chlorinated Coal and Aluminium Chloride

Van Krevelen *et al.*[1] have reported on the coupling of pitch molecules by chloromethylation and subsequent condensation under the influence of a Friedel-Crafts catalyst, while Iyengar, Banerjee and Banerjee[2] have claimed the alkylation of coals with benzyl chloride and aluminium chloride. But in these laboratories a similar type of reaction between a chlorinated low-rank coal (containing about 50 per cent of hydrolysable chlorine) and several aromatic compounds, in the presence of aluminium chloride, has given inconclusive results which suggest that alkylation may not have occurred during the reaction with benzyl chloride.

A chlorinated low-rank coal (Ellington High Main 81·0 per cent carbon, 5·1 per cent hydrogen, dry ash-free, N.C.B. Rank Code No. 802), prepared as previously described[3], was treated with an aromatic compound (Table 1) under suitable conditions. The dry chlorinated coal (7 gm.) was stirred with 100 ml. carbon tetrachloride (nitrobenzene was used as a solvent in the case of aniline) and 0·5–1·0 gm. of anhydrous aluminium chloride. A blue or green colour developed at this stage, suggesting initial formation of a complex with aluminium chloride. No hydrogen chloride was evolved. The aromatic compound (aniline, toluene, chlorobenzene, dimethyl aniline or dimethylbenzylamine) was then added (2–10 gm.) and the mixture refluxed for about 7 hr. After cooling and filtering, the product was washed with carbon tetrachloride and then dried at 100° C. *in vacuo*.

The results in Tables 1–2 show that, while the changes in elementary composition correspond with the expected reaction, the results do not definitely confirm the alkylation, since there was no corresponding release of hydrogen chloride. The increase in ash content suggests the presence of aluminium compounds in the products. It is doubtful if the results quoted by Iyengar, Banerjee and Banerjee[2], which do not include ash or chlorine contents,

Table 1

Ref. No.	Aromatic compound	Wt. gain on coal (per cent)	Elementary analysis of chlorinated coal and products Per cent d.a.f. D	H	N	S	O+ errors	Cl	Per cent ash air dry basis	Comment
—	—	—	63·0	3·4	1·4	1·8	9·7	20·7	2·2	Chlorinated coal
1	Aniline	36·8	70·9	4·7	5·9	1·7	8·5	8·3	6·0	Product
—	—	—	64·0	3·6	1·5	2·0	13·7	15·2	1·4	Chlorinated coal
2	Toluene	12·3	63·4	3·8	1·4	1·9	12·7	16·8	4·1	Product
3	Chlorobenzene	18·1	62·0	3·7	1·4	1·7	14·1	17·1	5·6	Product
4	Dimethylaniline	19·8	63·7	4·0	2·1	1·8	12·6	15·8	3·6	Product
—	—	—	61·0	3·3	1·3	2·0	13·7	20·0	1·3	Chlorinated coal
5	Dimethylbenzylamine	14·4	59·0	3·6	1·5	1·8	15·2	18·9	3·8	Product

Table 2. Changes in Elements during Reaction
(gm. atoms/100 gm. atoms original carbon)

Ref. No.	Aromatic compound	Change in number of gm. atoms C	H	N	Cl	Change in empirical formulæ Found addition of	Required for addition of compound
1	Aniline	+48	+52	+8·7	−5·2	$C_6H_{6\cdot5}N_{1\cdot1}(Cl_{0\cdot7})$	C_6H_5N
2	Toluene	+ 7	+ 6	nil	+1·4	C_7H_6Cl	C_7H_7
3	Chlorobenzene	+10	+ 9	nil	+1·0	$C_6H_{5\cdot4}Cl_{0\cdot6}$	C_6H_5Cl
4	Dimethylaniline	+17	+19	+1·2	+1·7	$C_8H_9N_{0\cdot6}Cl_{0\cdot8}$	$C_8H_{10}N$
5	Dimethylbenzylamine	+ 8	+14	+0·6	+0·6	$C_9H_{12}N_{0\cdot7}Cl_{0\cdot7}$	$C_9H_{12}N$

substantiate their claim that alkylation did in fact occur.

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BIOCHEMISTRY

Biological Dehydroxylation

The hydroxylation of aromatic compounds in the animal body to form phenols is a well-established biochemical reaction (see review[1]) and has been known for nearly a hundred years. It was in 1867 that Schultzen and Naunyn[2] first showed that benzene was converted to phenol in man and the dog. The reverse reaction, namely, dehydroxylation, is not well known. The first suggestion that such a reaction occurred *in vivo* was published in 1955 when Booth, Murray, DeEds and Jones[3] noted an enhancement of the *m*-hydroxyphenylacetic acid output in the urine of rabbits that had been dosed with 3,4-dihydroxyphenylacetic acid (homoprotocatechuic acid) or with the flavonoids, rutin and quercetin. It was suggested that the *m*-hydroxyphenylacetic acid arose by loss of the *para*-hydroxyl group of 3,4-dihydroxyphenylacetic acid. The excretion of increased amounts of *m*-hydroxyphenyl acids has since been observed after the administration of 3,4-dihydroxycinnamic acid (caffeic acid) to man, the rabbit and the rat[4,5] and after 3,4-dihydroxyphenylalanine (dopa) to the rabbit and the rat[4]. The ingestion of coffee leads to the excretion of increased amounts of *m*-hydroxyhippuric acid in human urine[6], and this has been ascribed by Booth *et al.*[5] to the breakdown of chlorogenic acid, which is the quinic acid ester of caffeic acid, and which occurs in coffee beans to the extent of 5 per cent on a dry weight basis. According to Armstrong *et al.*[6,7], *m*-hydroxybenzoic, -phenylacetic, -phenylpropionic and probably -phenyllactic acids occur in human urine, but the origin of these *meta*-acids is obscure. However, these acids could arise during metabolism by dehydroxylation of 3,4-dihydroxyphenyl acids (catechol acids). It is thus possible that dehydroxylation is a reaction of considerable metabolic significance.

It should be mentioned also that biological dehydroxylation has been observed in the quinoline series, for 4-hydroxyquinoline-2-carboxylic acid (kynurenic acid) is partly excreted as quinoline-2-carboxylic acid (quinaldic acid) in man and the rat[8], and 4,8-dihydroxyquinoline-2-carboxylic acid (xanthurenic acid) is excreted as 8-hydroxyquinoline-2-carboxylic acid in the rat[9], but 4,8-dihydroxyquinoline is not dehydroxylated[9]. However, the hydroxyl group in the 4 position of quinoline is not strictly phenolic, and the mechanism of its dehydroxylation may not be the same as the removal of the phenolic group in the catechol acids.

In order to put the dehydroxylation of the catechol acids on a sound basis we have synthesized [carboxy-^{14}C] 3,4-dihydroxyphenylacetic acid and administered this compound by mouth to rabbits. The various metabolites of this acid were then determined by isotope dilution and paper chromatographic techniques after acid hydrolysis of the urine. The results are shown in Table 1.

Table 1 shows that in 44 hr. after dosing with the homoprotocatechuic acid labelled with carbon-14 about 85 per cent of the carbon-14 is excreted in the urine, and this can be accounted for as four compounds. The main excretory product is the original acid. However, both *m*- and *p*-hydroxyphenylacetic acids are labelled and so is 4-hydroxy-3-methoxyphenylacetic acid (homovanillic acid). The last acid

Table 1. Metabolites of [^{14}C]3,4-Dihydroxyphenylacetic Acid (Dose, 100 mgm./kgm.)

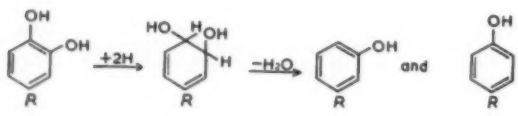
	Percentage of dose* excreted in 44 hr. determined by isotope dilution
3,4-Dihydroxyphenylacetic acid	63
m-Hydroxyphenylacetic acid	14
p-Hydroxyphenylacetic acid	1·4
4-Hydroxy-3-methoxyphenylacetic acid (homovanillic acid)	5·6
Sum of metabolites	84
Radioactivity of urine after 44 hr.	85·5
Radioactivity of urine after 8–9 days	100·3

* Mean value of three animals

is a known metabolite of homoprotocatechuic acid, of dopa[4], and of 3,4-dihydroxyphenylethylamine (3-hydroxytyramine or dopamine)[10]. Its isomer, 3-hydroxy-4-methoxyphenylacetic acid (homo-*iso*-vanillic acid), was looked for in our experiments but it was not found.

Now the isotope dilutions in our experiments were carried out on ether extracts of the acid-hydrolysed urines, and it might be argued that the *m*-hydroxyphenylacetic acid was an artefact. However, the *m*-acid was found in unhydrolysed urines by paper chromatography in non-acidic solvents and by isotope dilution. In fact, the amount found in unhydrolysed urines was no different from that found in acid-hydrolysed urines, and it was concluded that *m*-hydroxyphenylacetic acid was a true urinary metabolite of homoprotocatechuic acid.

The formation of *p*-hydroxyphenylacetic acid is interesting because it shows for the first time that the *m*-hydroxyl group of a catechol acid can also be lost *in vivo*. A mechanism for the dehydroxylation of catechol acids has been suggested by one of us[11]. It is suggested that homoprotocatechuic acid is hydrogenated *in vivo* to 3,4-dihydro-3,4-dihydroxyphenylacetic acid, which could then lose water to yield *m*- or *p*-hydroxyphenylacetic acid or both:



where $R = CH_2COOH$. The nature of the R group is important for it would influence how much *m*- and *p*-dehydroxylation occurred. When $R = CH_2COOH$, more *p*-dehydroxylation than *m*- is to be expected and this is in accord with the figures in Table 1, where the ratio *m*-acid/*p*-acid is 10, which means that there is ten times as much *para*-dehydroxylation of homoprotocatechuic acid as *meta*- in the rabbit.

Dehydroxylation could also be a metabolic reaction of the catechol amines, adrenaline and noradrenaline. *p*-Dehydroxylation of adrenaline would give the known sympathomimetic agent, phenylephrine (or meta-synephrine) base and *m*-dehydroxylation, synephrine base. These two amines could be normal metabolites of the body.

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Note added, August 19. Dr. Sidney Udenfriend (National Heart Institute, Bethesda, Md.) has informed us that he has found synephrine in human urine, and an account of this finding is being prepared for publication. He has also directed our attention to a communication by himself and his co-workers (see Sjoerdsma *et al.*, *Science*, **130**, 225; 1959) on the finding of *m*-tyramine (*m*-hydroxyphenylethylamine) in the urine of humans dosed with the monoamine oxidase inhibitor, 1-phenyl-2-hydrazinopropane (*JB*-516 or 'Catron'). It is possible that *m*-tyramine is a product of the dehydroxylation of dopamine *in vivo*.

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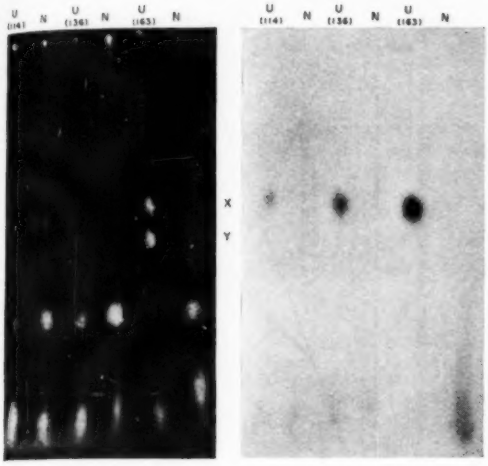
Ultra-Violet Photography of Fluorescent Spots on Chromatograms of Biological Extracts

The use of ultra-violet light to detect and photograph chromatographed compounds absorbing in the region of 254 mμ is well known[1]. In the course of investigating a number of unknown compounds found on chromatograms of plasma extracts, a simple technique was developed for photographing spots which fluoresce in ultra-violet light at 360 mμ. This consists of interposing a Kodak 2*A* gelatin filter, which absorbs radiant energy below 405 mμ, between the chromatogram and the contact paper ('Kodabromide *F*5'). The filter is enclosed for protection between 1/16 in. glass plates, bound with tape at the edges. The chromatogram is exposed for approximately 30 sec. to ultra-violet light from a 365-mμ source ('Mineralight' handlamp, Ultraviolet Products, Inc., San Gabriel, Calif.) at a distance of 1 ft. The photograph is then developed in the usual way.

To illustrate the application of the method, Figs. 1*a* and *b* show respectively photographs taken at 254 mμ without a filter (absorbing compounds), and at 365 mμ with the filter (fluorescing compounds), of a chromatogram of plasma extracts from three normal subjects and three patients with uræmia. In Fig. 1*a* it can be seen that the plasma concentration of the ultra-violet-absorbing substances *X* and *Y* increases with increasing levels of blood urea nitrogen. In Fig. 1*b* the increased amounts of the fluorescent substance *X* in the uræmic patients' plasma, compared with that of the normal subjects, is clearly demonstrated. Further work on the identification of both compounds is at present being undertaken.

The technique described dispenses with the need for a camera, and is now used routinely in this laboratory to supplement the information obtained



(*a*) (*b*)

Fig. 1. Ultra-violet photographs of a descending chromatogram in *n*-butanol/water (86 : 14), taken at 254 mμ (*a*) and at 360 mμ with filter (*b*). *N*, Plasma extract from normal subjects; *U*, plasma extract from patients with uræmia; *X*, *Y*, unknown compounds. Figures in brackets refer to levels of blood urea nitrogen

from 254-mμ photographs. It is particularly useful for substances such as 5-hydroxyanthranilic acid, which are not detected by the latter method. For compounds such as *X*, which fluoresce in ultra-violet light and also absorb, the fluorescent technique is the more sensitive. It should be applicable to all substances in which visible fluorescence is activated at wave-lengths below 405 mμ, and thus provides a general extension of the method described by Smith and Markham[2], in which a cellulose nitrate filter cutting off wave-lengths below 320 mμ is used.

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Oxidative Activity of a Particulate Fraction from *Rumex* Virus Tumour Tissue

ALTHOUGH the capacity of cytoplasmic particles from plant tissues to oxidize Krebs-cycle intermediates has been clearly demonstrated[1], only one investigation to date has been reported on the oxidative reactions of particulate fractions from plant tissue cultures[2]. Such investigations are of particular interest and importance in that they permit an elucidation of the biochemical differences between normal (callus) and neoplastic plant tissues and between tissue cultures and the parent plant parts. This work is concerned with the oxidative activity of a particulate fraction from virus tumour tissue of Black's original R_1 strain from *Rumex acetosa* L.

The tissue was grown on medium No. 24 of Burkholder and Nickell[3] under the conditions previously described[4]. Approximately 15 gm. of tissue, 4–6 weeks old, was ground in a mortar and pestle with 30 ml. of buffer containing potassium dihydrogen phosphate, 0·1 *M*; sucrose, 0·5 *M*; dipotassium salt of ethylenediamine tetraacetic acid, 0·01 *M*; *p*H 7·3. A small quantity of quartz sand was added to aid in grinding. The macerate was strained through cheese-cloth and centrifuged at 500*g* for 10 min. The resultant supernatant was centrifuged at 20,000*g* for 20 min. and the pellet finally obtained was suspended in 3·0 ml. of buffer containing potassium dihydrogen phosphate, 0·02 *M*; sucrose, 0·4 *M* and magnesium chloride, 0·005 *M*, *p*H 7·2.

All the above operations were carried out at 0–4° C. Manometric measurements were conducted at 30° C. using standard Warburg apparatus. Nitrogen content of the particulate suspensions was determined on 1·0-ml. samples of suspensions which had been diluted 1 : 10 with distilled water. The samples were digested by a micro-Kjeldahl method and nesslerized. Nitrogen was determined colorimetrically in a Klett–Summerson photoelectric colorimeter equipped with a 490-mμ filter.

All reagents used were of the highest quality available commercially.

The particulate suspension was yellow in colour, and microscopic examination with an oil-immersion objective showed that it consisted of oval particles which stained with janus green *B*. These particles were very similar in appearance to particles commonly referred to as mitochondria.

The particulate suspension catalysed the oxidation of citrate, α-ketoglutarate, succinate, fumarate and malate (Table 1). The rate of pyruvate oxidation was very low, but the addition of catalytic amounts of malate resulted in a considerable increase in pyruvate oxidation (Table 2). The use of malate as a 'sparker' in pyruvate oxidation has been previously reported[5]. Of the other Krebs-cycle acids utilized as substrates, succinate was oxidized most rapidly while the rate of fumarate oxidation was repeatedly the lowest obtained. These findings could account for the reported accumulation of fumarate in older tumour tissues[4].

A cytochrome oxidase system is present in *Rumex* tumour tissue[6] although the rate of oxidation of all but two of the substrates utilized, citrate and malate, was not significantly enhanced by the addition of cytochrome *c*. The failure of added cytochrome *c* to

Table 1. OXIDATION OF KREBS-CYCLE ACIDS BY A PARTICULATE FRACTION FROM *Rumex* VIRUS TUMOUR TISSUE

Substrate	Mm.³ O_2/mgm. N/hr.* (−) Cytochrome *c*	(+) Cytochrome *c*
Pyruvate	19	—
Citrate	53	118
α-Ketoglutarate	75	73
Succinate	183	191
Fumarate	41	48
Malate	83	127

Complete reaction mixture: Particulate suspension, 0·5 ml.; substrate, 0·02 *M*; adenosine monophosphate, 0·001 *M*; diphosphopyridine nucleotide, 0·0005 *M*; diphosphothiamine, 0·0001 *M*; coenzyme *A*, 0·000025 *M*; glucose, 0·02 *M*; potassium phosphate (monobasic), 0·02 *M*; sucrose, 0·4 *M*; magnesium chloride, 0·005 *M*; cytochrome *c* (where added), 0·0001 *M*. Total volume, 3·0 ml.; temperature, 30° C.; *p*H, 7·2; gas phase, air. Centre well of each Warburg vessel contained 0·2 ml. 20 per cent potassium hydroxide and a filter paper wick.

* Corrected for low rate of endogenous oxygen uptake.

Table 2. PYRUVATE OXIDATION BY A PARTICULATE FRACTION FROM *Rumex* VIRUS TUMOUR TISSUE

Substrate	Mm.³ O_2/mgm. N/hr.*
Pyruvate	23
Pyruvate + malate (0·001 *M*)	103
Pyruvate + cytochrome *c*	23
Pyruvate + malate + cytochrome *c*	123

Reaction mixture same as in Table 1

* Oxygen uptake in presence of malate (0·001 *M*) showed no measurable increase over endogenous rate.

enhance oxidation has been interpreted as indicating that the mitochondrial complex has been isolated in reasonably intact form, and that sufficient cytochrome c is bound to the particles[7]. It is possible that in cases where added cytochrome c failed to enhance the rate of oxidation of substrate other factors may be limiting[8].

Evidence is presented to demonstrate that *Rumex* virus tumour tissue cultivated *in vitro* contains particles which possess the capacity characteristic of plant mitochondria to oxidize Krebs-cycle acids.

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Enzyme Repression as the Control Mechanism in the Synthesis of Induced β-Galactosidase

It is known that the mechanism controlling the level (synthesis) of the constitutive enzymes in cells is enzyme repression[1]. An early example for enzyme repression was the inhibition of the synthesis of constitutive β-galactosidase by lactose or galactose[2]. In the present investigation I have examined the regulation of the synthesis of induced β-galactosidase.

The strain *Escherichia coli ML* 30 and the medium *M*–9 (ref. 3) which contains either 2 mgm./ml. maltose—twice recrystallized from 80 per cent ethanol—or glycerol as sole source of carbon were used in this work. The inducer, *iso*propyl-thio-β-D-galactoside[4] or lactose, was added to the exponentially growing culture, containing 30 μgm/ml. bacterial dry weight, at 37° C. on a rotary shaker. At intervals, during the first one and a half division after the addition of inducer, samples were taken for galactosidase and dry-weight assay. For the enzyme assay, 0·5-ml. aliquots of the culture were pipetted into tubes containing 0·5 ml. chloramphenicol solution (50 μgm./ml.) in 0·01 *M* sodium phosphate (*p*H 7). After toluene treatment at 37° C., 4 ml. of a solution of $2{\cdot}5 \times 10^{-3}$ *M* *o*-nitrophenyl-β-D-galactoside in 0·01 *M* sodium phosphate were added and the tubes incubated for a measured time, until the desired intensity of colour had developed. The reaction was stopped by the addition of 5 ml. of 0·4 *M* sodium carbonate. After centrifuging the cells, the optical density was measured at 420 mμ. One unit of enzyme is the amount which, under these conditions, hydrolyses 1 mμmole *o*-nitrophenyl-β-D-galactoside per min. The galactosidase activity, *Z*, in units galactosidase per ml. is plotted against dry-weight of bacteria, *X* in μgm. per ml. The rate of induction is defined as the differential rate of synthesis, $p = \Delta Z/\Delta X$ (ref. 5). Cell density was determined by the aid of a Pulfrich nephelometer. Standard curves were used to convert the readings obtained to dry-weight of bacteria per ml.

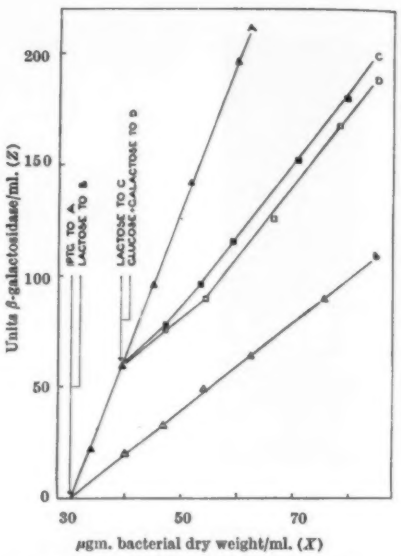

Fig. 1. Effect of lactose and its metabolites (glucose + galactose) on the synthesis of β-galactosidase induced by *iso*propyl-thio-β-D-galactoside. The exponentially growing cells, on maltose as carbon source, was induced with 10^{-3} *M* *iso*propyl-thio-β-D-galactoside (*A*) or with 10^{-3} *M* lactose (*B*). At the points indicated by an arrow, 10^{-3} *M* lactose (*C*) or 5×10^{-4} *M* glucose + 5×10^{-4} *M* galactose (*D*) was added respectively to the induced cells

As shown in Fig. 1, the rate of synthesis of β-galactosidase induced by *iso*propyl-thio-β-D-galactoside is greater ($P = 6{\cdot}6$) than in the case of lactose of the same concentration ($P = 2{\cdot}0$) if the cells were grown on maltose as carbon source. The addition of lactose to cells induced by *iso*propyl-thio-β-D-galactoside—although lactose is an inducer in itself—inhibits the synthesis of enzyme. From the kinetics of the inhibition, it is not the lactose itself which causes inhibition but its metabolic products, namely, glucose and galactose. This inhibitory effect is very similar to that described previously concerning the inhibition of constitutive β-galactosidase synthesis by enzyme repression[2].

If the result shown in Fig. 1 may be generalized, that is, in the case of a metabolizable inducer the rate of synthesis of the induced enzyme is being regulated not only by the structure and concentration of the inducer but also by its metabolites, then it may be assumed that the same inducer will show a different inductive activity in cells grown with different carbon sources.

As seen in Fig. 2, if glycerol is used as source of carbon, the inductive activity of lactose in small concentrations is nearly the same as that of *iso*propyl-thio-β-D-galactoside. If an increasing concentration of lactose is used, then the enzyme induced by it produces great amounts of hexose. The metabolism of the cell grown on glycerol is not able to utilize this excess of hexose, and in consequence it will inhibit the synthesis of the enzyme. This inhibition will be suppressed only when the excess of hexose is metabolized by the cell.

From a theoretical point of view it is very important that *iso*propyl-thio-β-D-galactoside is a non-metabol-

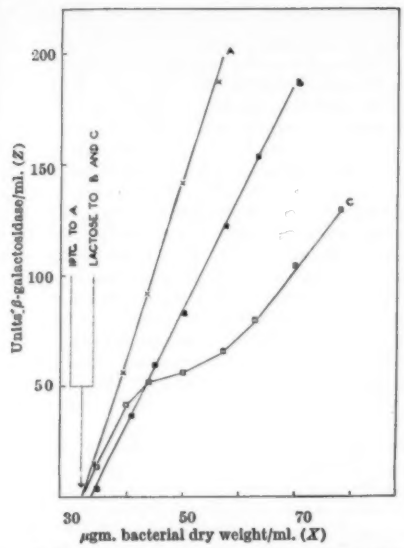

Fig. 2. Synthesis of induced β-galactosidase in cells grown on glycerol as carbon source. At the point indicated by an arrow, the exponentially growing cells were induced with 10^{-3} *M* *iso*propyl-thio-β-D-galactoside (*A*), or 2×10^{-4} *M* lactose (*B*), or 10^{-3} *M* lactose (*C*)

izable inducer, that is, no metabolite is produced by the induced enzyme that would enter the cell metabolism. Consequently, experiments carried out with such inducers will give no answer to the question whether the mechanism of the induction or its regulation is influenced or not by the metabolites of the inducer.

These investigations show that the rate and level of synthesis of the induced enzyme is determined by the ratio of the concentration of the inducer and of its metabolites, glucose and galactose, causing enzyme repression. Further investigations in this direction are in progress.

I thank Dr. J. Monod for the supply of the strain of *Escherichia coli* used in this work.

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A Method for the Direct Detection of Proteolytic Enzymes after Electrophoresis in Agar Gel

SEVERAL methods have been developed for the detection of different enzymatic reactions in agar gel[1]. The present communication describes a method for the direct detection of proteolytic enzymes following electrophoresis in agar gel.

The principle of the method is the following: after the electrophoretic separation of the enzyme preparation, the agar plate is immersed in a bath containing a protein which is susceptible to degradation by the proteolytic enzyme. After incubation the plate is fixed, dried and coloured in the normal way[2]. The sites on the plate possessing a proteolytic activity toward the chosen substrate are revealed as weakly or non-coloured zones against an evenly coloured background. This coloured background is due to the protein substrate which diffuses into the agar gel during the incubation. In the zone where the proteolytic enzyme is situated all, or a portion of, the substrate is degraded. The coloration in this zone is non-existent or weak because the products of the degradation are not fixed by the acid fixator nor coloured by amido black.

The experimental conditions (buffer, *p*H, ionic strength, etc.) used for the preliminary electrophoretic separation may differ from those employed for the detection of the proteolytic enzyme, as these two operations are completely independent. For optimum results with each enzyme preparation and corresponding substrate, it is necessary to adjust the reaction conditions, that is, the *p*H, the temperature and time of incubation, the substrate concentration and the quantity of enzyme employed.

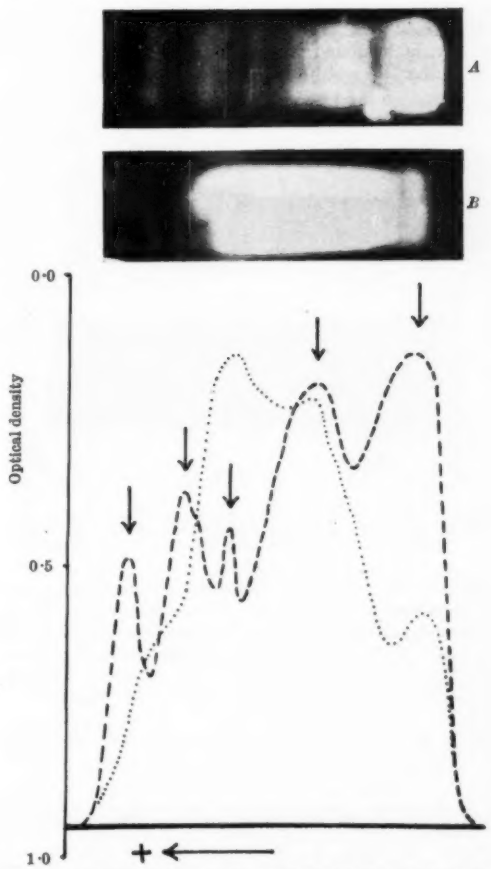

Fig. 1. Agar electrophoresis. *A*, Proteolytic activity of a purified non-crystallized trypsin preparation ('Difco'): *B*, proteolytic activity of a twice-crystallized trypsin preparation (Nutritional Biochemical Corp.); bottom, photometric scanning of upper images: ——, *A*; ...., *B*

The following examples illustrate two of the different types of application of the method.

The proteolytic activity of preparations of trypsin have been studied in the following manner: freshly prepared trypsin solution (100 μgm. per analysis) were subjected to electrophoresis according to the technique of Grabar and Williams[3] for 60 min. at a potential difference of 6–7 V./cm. in agar gel of 1 per cent containing sodium veronal buffer (*p*H 8·2, Γ/2 0·025). After electrophoresis the plates were immersed in a 0·5 per cent solution of casein in veronal buffer (*p*H 8·2, Γ/2 0·05) and incubated with occasional stirring for 45 min. at 25° C. They were then fixed for 2 hr. in a 50 per cent ethanol solution containing 3 per cent acetic acid, dried under filter paper and coloured by amido black[2]. The results obtained with two commercial preparations of trypsin are shown in Fig. 1. The heterogeneity of these preparations is obvious.

The proteolytic activity of an aqueous extract of rabbit spleen has also been studied by carrying out the electrophoresis at *p*H 8·2 and then incubating the plate in a solution of human serum albumin at *p*H 3·5 (the technical details of the experiment will be given elsewhere[4]). A parallel electrophoresis of the spleen extract was done and stained for protein in the usual way[2]. Fig. 2 shows that despite the heterogeneity of the spleen extract its proteolytic activity is localized in one well-defined zone, thus confirming the results of Lapresle and Webb[5].

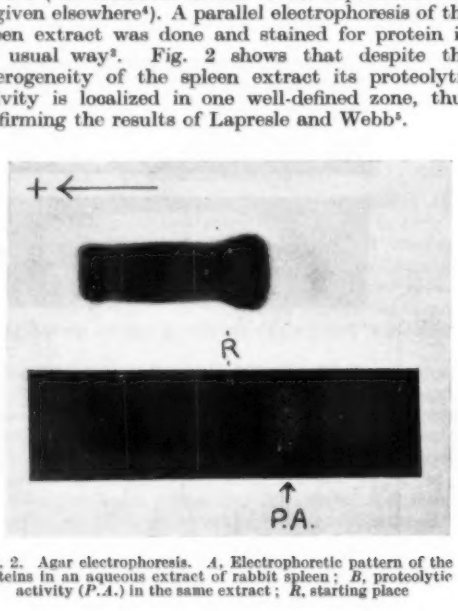

Fig. 2. Agar electrophoresis. *A*, Electrophoretic pattern of the proteins in an aqueous extract of rabbit spleen; *B*, proteolytic activity (*P.A.*) in the same extract; *R*, starting place

These two examples illustrate one advantage of this method. It permits one to determine if the heterogeneity of an enzyme preparation is due to the existence of several constituents possessing a proteolytic activity (Fig. 1) or to the presence of non-enzymatically active protein impurities (Fig. 2).

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Neurohormonal Properties of Royal Jelly

Royal jelly has significance in polymorphic development of bees. Bee larvæ fed on an over-abundance of royal jelly develop into queens; those given food differing quantitatively and qualitatively become worker bees[1]. Royal jelly has other interesting properties, for evidence is available of its therapeutic value in transplantable mouse leukæmia[2] and of the presence of an antibiotic[3]. These effects might be termed anti-growth properties. It is remarkable that royal jelly is stated to contain acetylcholine[4] in an amount calculated to be about six times that found in the brain of insects[5]. Nothing is known about the origin of acetylcholine in royal jelly or indeed whether this substance, obtainable from bees other than those used by Henschler[4], contains acetylcholine. The occurrence of a neurohormone in royal jelly is of considerable interest for it suggests that acetylcholine may have a function different from that associated with nervous transmission.

Partition chromatography and the frog rectus abdominis muscle were used to identify acetylcholine. Royal jelly was heated to boiling point in a small volume of distilled water, *p*H 3·9, and when the extract was cool, trichloracetic acid was added to give a final concentration of 1 per cent. The extract was centrifuged at 4,000 r.p.m. for 5 min., the supernatant decanted and shaken with an equal volume of ether for four successive extractions. The resulting clear liquid was evaporated to a small volume *in vacuo* and spotted on Whatman No. 1 filter paper. For reference, standard solutions of acetylcholine were used with trichloracetate, bromide or chloride associated anions. Chromatograms were run in wet butanol as the solvent, and choline esters were detected by the use of Dragendorff's reagent, which reacts to give a pink spot. The results show that extracts of royal jelly gave one spot with an R_F of 0·45 identical to that found with a solution of acetylcholine trichloracetate. By use of the frog rectus abdominis muscle it was determined that 1 gm. of royal jelly contained an active substance equivalent in activity to 683±64 μgm. of acetylcholine bromide. The active substance was readily hydrolysed by bovine purified erythrocyte or cockroach acetylcholinesterase and destroyed by alkali and heating; stability was found at *p*H 3·9. Atropine reduced contraction of the frog muscle. On the basis of this evidence it is suggested royal jelly contains acetylcholine, thus confirming the report of Henschler[4] for the royal jelly of European bees. It was determined that acetylcholine was not destroyed in royal jelly held in storage for about two years. The *p*H of royal jelly, 3·9–4·1, appears to be about optimal for the preservation of acetylcholine.

The hypopharyngeal glands of nurse worker bees are said to produce royal jelly[1]. These glands and the post-cerebral glands were used as sources for choline acetylase. The synthesis medium contained optimum amounts of coenzyme *A*, transacetylase, acetyl-phosphate, choline salts, and phosphate buffer (*p*H 6·9). Glands dissected from bee heads were frozen immediately in 0·9 per cent potassium chloride and homogenized just before use. No synthesis of acetylcholine was found with gland extracts although brain tissue synthesized up to 50 mgm. acetylcholine per gm. of brain in 1 hr. Furthermore it was determined by use of a standard manometric technique, with 0·01 *M* acetylcholine as substrate, that glands did not contain acetylcholinesterase. It is concluded

that, although a hydrolysing esterase was absent, no evidence has been obtained for the presence of choline acetylase in gland tissue to account for the acetylcholine of royal jelly. Extra-cellular enzymic synthesis of acetylcholine could occur in the lumen of glands, but it is doubtful whether this would happen at royal jelly *p*H, for optimal choline acetylase activity occurs at *p*H 7·0–7·5 with acetate as the acetyl donor[6].

Goldschmidt and Burkert[7] report the occurrence of acetylcholine in honey. This fact dispels evidence of an especial property of the secretion of hypopharyngeal glands, but suggests that acetylcholine may be a necessary inclusion in both honey and royal jelly, for these substances are the natural food of bees. Disregarding the possibility that acetylcholine appears in royal jelly or honey during muscular activity of the pharynx necessary for the expulsion of these substances from worker bees, it could be that acetylcholine has ecto-hormonal properties. Acetylcholine has no apparent effect when injected into insects in high amounts, but the possibility exists that it has a muscarinic action on the gut of bee larvæ, and in this way promotes rapid ingestion and movement of food. Choline as a hydrolysis product would provide a source of methyl groups for the process of transmethylation, which may be a factor in growth. In any event it would appear that acetylcholine of royal jelly and honey may have another purpose in insects different from that thought to be associated with the neurohormone in nervous tissue.

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Effect of Fluoride on the Biogenesis of Thyroid Hormones

The biogenesis of thyroid hormones occurs in several successive stages. Accumulation of iodine in the thyroid may be considered as the first of these, while the second is represented by the binding of 'active iodine' on the tyrosine radical, 3-monoiodotyrosine being formed in the process. It would seem that a further enzymatic system[1] is responsible for the production of 3 : 5-diiodotyrosine, and a fourth phase in this biogenesis consists in the synthesis of iodinated thyronines into thyroxine, 3 : 5 : 3′-triiodothyronine, 3 : 3′ : 5′-triiodothyronine and 3 : 3′-diiodothyronine. In addition to these biosynthetic enzyme systems intervening in the thyroid, it is necessary to mention also the deiodinating enzyme, acting selectively on iodinated tyrosines and the proteolytic enzymes which liberate amino-acids from the thyroglobulin.

Table 1. Percentage of Iodinated Amino-acids and Iodide in Pancreatic Hydrolysates of Thyroglobulin in the Rat assessed Chemically (Iodine-127)

	Control ($n = 4$)	Fluorized ($n = 7$)
Start	9·9	11·2
3 : 5-Diiodotyrosine	47·6	46·5
3-Monoiodotyrosine	23·2	23·5
Iodide	5·9	5·7
Thyroxine	8·7	8·9
3 : 5 : 3′-Triiodothyronine	4·3	3·6
Total iodine in the thyroid gland	6·73 μgm.	6·62 μgm.

The present experiment bears on the effects of fluoride on the biogenesis of thyroid hormones in rats (females, weight 180–230 gm.). The animals received a daily dose of 2·2 μgm. of iodine in their basic diet[2] or 0·2 μgm. of iodine in a carbohydrate diet[3] in addition to 750 μgm. of fluoride given by means of a gastric tube in 1·0 ml. of water. Two months following the intraperitoneal application of 25 μc. of iodine-131 without carrier, the rats were killed at various time-intervals by bleeding under ether anæsthesia. The thyroids were homogenized and hydrolysed by means of pancreatine at 38° C. for 24 hr. 0·03 ml. of the hydrolysate was transferred directly to Whatman No. 1 chromatographic paper and developed in the *n*-butanol/dioxane/ammonia system (4 : 1 : 5) at 35° C. (ref. 4). The chromatograms were then analysed on an automatic radiopaper chromatographic recorder (Frieseke-Hoepfner). The percentage representation of iodinated amino-acids was assessed by chemical methods. This same procedure was also used for the assay of the protein-bound and total iodine-levels in serum and in urine[5].

The quantity of ingested fluoride had no effect either on body-weight, weight of thyroid, total composition of iodinated amino-acids or amount of iodide present in the thyroid (Table 1); it was also without effect on the iodine excreted in the urine and on the protein-bound and total iodine-levels in the rats receiving 2·2 μgm. of iodine daily. At the daily dose-rate of 0·2 μgm. of iodine, the protein-bound iodine-level in fluorized animals ($n = 12$) was lower than in the controls ($n = 7$), receiving the same diet ($P < 0·05$). In both groups, however, investigation with iodine-131 revealed a reduced rate of biogenesis of thyroxine and 3 : 5 : 3′-triiodothyronine within 12 hr. following administration of iodine-131. Fig. 1 shows a characteristic autoradiochromatogram of thyroglobulin hydrolysates of rats with a daily iodine intake of 2·2 μgm. The animals were killed 64 min. after the administration of iodine-131. The statistical evaluation of differences in rats receiving a daily intake of 0·2 μgm. of iodine is given in Table 2. Fluorized rats showed a significantly decreased amount of thyroxine ($P < 0·01$) and of 3 : 5 : 3′-triiodothyronine ($P < 0·05$) as against the controls. At a later date, after the application of iodine-131, the amount of thyroxine and 3 : 5 : 3′-triiodothyronine was the same in both the groups without regard to the diet.

Table 2. Thyroxine and 3 : 5 : 3′-Triiodothyronine Ratios in Controls and Fluorized Rats with Daily Intake of 0·2 μgm. of Iodine, 8 hr. 32 min. following Application of 25 μc. of Iodine-131

	Control ($n = 2$)	Fluorized ($n = 6$)
Thyroxine	21·31 ± 2·75*	8·00 ± 3·20
	$t = 5·24$	$P < 0·01$
3 : 5 : 3′-Triiodothyronine	9·37 ± 3·16	4·43 ± 1·69
	$t = 3·04$	$P < 0·05$

* The values were obtained planimetrically and are given in sq. cm.

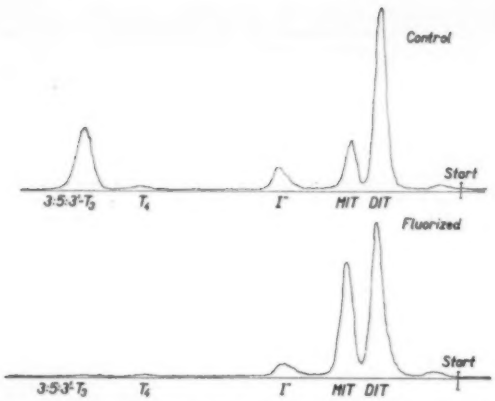

Fig. 1. Chromatograms of hydrolysed thyroglobulin in control and in fluorized rats with daily iodine intake of 2·2 μgm., 64 min. following administration of 25 μc. of iodine-131. 3 : 5 : 3′-T_3 = 3 : 5 : 3′-triiodothyronine; T_4 = thyroxine; I^- = iodide; *MIT* = 3-monoiodotyrosine; *DIT* = 3 : 5-diiodotyrosine

This finding is considered as confirmation of the fact that a special enzymatic system, which it is possible to inhibit by means of fluoride, is responsible for the synthesis of thyroxine and 3 : 5 : 3′-triiodothyronine.

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BIOPHYSICS

A Water-insoluble Trypsin Derivative and its Use as a Trypsin Column

The conversion of enzymes into water-insoluble products possessing specific catalytic activity is of interest since such 'water-insoluble enzymes' may readily be removed from the reaction mixture, and can be used for the preparation of columns with enzymic activity. If stable, they may be employed repeatedly to induce specific chemical changes in relatively large amounts of substrate. Adsorption techniques were applied to combine enzymes with insoluble carriers[1]. These procedures led, however, to partial denaturation and resulted in preparations from which the reversibly adsorbed enzyme was removed while in contact with substrate. In order to strengthen the linkage between enzyme and carrier their attachment by chemical covalent bonds seemed preferable. Such links should obviously be carried out by functional groups non-essential for enzymic activity. Furthermore, the attachment of the enzyme to the carrier by flexible polymeric side-chains would ensure free movement of the catalyst molecules in the reaction mixture.

Various attempts to attach antigens and antibodies by chemical bonds to water-insoluble high molecular weight compounds have been reported[2]. The immunologically active columns obtained were used in the purification of the corresponding antibodies and antigens, respectively. So far as we are aware, however, only one paper deals with the chemical binding of enzymes to water-insoluble polymers[3]. Polyaminostyrene was used as carrier, and enzymes such as pepsin and carboxypeptidase were coupled with the polymer through azo bonds. The chemical properties as well as the enzymic activity of the final products were poorly characterized.

In the following we describe the preparation of a water-insoluble trypsin making use of the ideas mentioned above. A polytyrosyl trypsin containing tyrosyl peptide side-chains was prepared by initiating the polymerization of N-carboxy-L-tyrosine anhydride with trypsin. The trypsin derivative thus obtained was water-soluble and retained full enzymic activity. On coupling with a diazotized copolymer of *p*-aminophenylalanine and leucine it yielded the required water-insoluble trypsin. The latter served for the preparation of an active trypsin column.

Crystalline trypsin (75 mgm.) was dissolved in phosphate buffer, *p*H 7·2, ionic strength 0·25 (8 ml.), and the solution was mixed with N-carboxy-L-tyrosine anhydride[4] (80 mgm.) in dioxane (2 ml.). The mixture was kept at 2° C. for 24 hr. with magnetic stirring. Afterwards it was dialysed for five days against a large volume of 0·0025 *N* hydrochloric acid and was then lyophilized. The polytyrosyl trypsin obtained was free of monomeric tyrosine and of low molecular weight tyrosine peptides. A comparison of the ultra-violet absorption of polytyrosyl trypsin at 293·5 mμ in 0·1 *N* sodium hydroxide with that of trypsin revealed that the tyrosine content of the enzyme had increased from 2·8 per cent to 9·0 per cent.

The copolymer of *p*-amino-DL-phenylalanine and L-leucine was prepared by copolymerization of α,N - carboxy - *p* - amino,N - benzyloxycarbonyl - DL-phenylalanine anhydride[5] (3·5 gm.) and N-carboxy-L-leucine anhydride[5] (1·5 gm.) in dioxane (100 ml.) using triethylamine (0·1 ml.) as initiator. The product formed after standing for three days at room temperature was precipitated with water, dried and the benzyloxycarbonyl groups were removed with anhydrous hydrogen bromide in glacial acetic acid. Hydrolysis with 6 *N* hydrochloric acid for 24 hr. yielded *p*-aminophenylalanine and leucine in a molar ratio of 1 : 5. The copolymer was diazotized with nitrous acid and the diazonium salt formed precipitated at *p*H 7·5 with a concentrated sodium acetate solution. Coupling with polytyrosyl trypsin was effected in phosphate buffer, *p*H 7·2, ionic strength 0·25, at 2° C. with magnetic stirring. The reaction mixture was kept in the cold for 20 hr. and the light brown water-insoluble trypsin was separated by centrifugation and washed with 10 per cent sodium acetate solution, followed by 0·0025 *N* hydrochloric acid until no tryptic activity could be detected in the washings. The water-insoluble preparation was shown to contain 21 per cent protein as estimated from the amount of valine determined chromatographically[6] after acid hydrolysis.

The rate of hydrolysis of benzoyl-L-arginine methyl ester (4 mgm. per ml.) at *p*H 7·8 and 25° C., by

water-insoluble trypsin (1 mgm. per ml.), was equal to that by 0·045 mgm. per ml. crystalline trypsin. Since 1 mgm. water-insoluble trypsin contains 0·21 mgm. bound protein, the catalytic activity of the latter towards benzoyl-L-arginine methyl ester amounts approximately to a fifth of that of the free enzyme. The enzymic activity of water-insoluble trypsin remained practically unaltered when kept under 0·0025 *N* hydrochloric acid at 2° C. for several months. The remarkable stability of the water-insoluble trypsin is most likely due to the blocking of the ε-amino lysine groups of the enzyme on one hand, and to the fixation of the enzyme molecules to the water-insoluble copolymer on the other. The former leads to a decrease in the number of enzyme peptide bonds susceptible to tryptic digestion, while the latter inhibits interaction between trypsin molecules, thus diminishing autodigestion. Complete inactivation of water-insoluble trypsin could be effected by heating to 100° C. for 15 min. at *p*H 7·5. Addition of an excess of soybean or pancreatic trypsin inhibitor caused only partial inhibition of the enzymic activity.

A trypsin column of 0·8 cm. diameter and 5·0 cm. height was prepared by mixing water-insoluble trypsin (20 mgm.) with an inert polyvinyl resin ('Geon, 426', B.F. Goodrich Co.) (2·0 gm.) in 0·0025 *N* hydrochloric acid (20 ml.) and by pouring the mixture into a glass tube. Prior to use the column was washed with the suitable buffer. The effect of rate of flow of substrate on the degree of hydrolysis was tested in the case of L-arginine methyl ester. When a solution containing 7·0 mgm. substrate per ml. phthalate buffer of *p*H 6·0 and ionic strength 0·19 was passed through the column at 25° C. at different flow-rates (0·125 ml.–1·0 ml. per min.) the percentage of ester hydrolysed was found to be inversely proportional to the rate of flow. The column had retained full enzymic activity, even after the hydrolysis of as much as 4·0 gm. of L-arginine methyl ester during a period of two weeks.

On passing through the column a solution of poly-L-lysine hydrobromide (10 mgm. per ml. phosphate buffer, *p*H 7·4, ionic strength 0·13) at a rate of 1 ml. per hr., the effluent was found to contain dilysine, trilysine, tetralysine and traces of lysine[7]. Protamine and insulin oxidized by performic acid could be digested under similar conditions to products identical to those formed by normal tryptic digestion as detected by paper chromatography.

To test the action of the water-insoluble enzyme on a native protein, water-insoluble trypsin (1 mgm.) was mixed with a solution of 0·68 per cent rabbit myosine in 0·5 *M* potassium chloride, 0·03 *M* phosphate, *p*H 7·0 (5 ml.), and the reaction mixture was incubated at 22° C. After given time-intervals, 1-ml. aliquots were withdrawn, the water-insoluble trypsin was removed by centrifugation and the ultracentrifuge pattern of the supernatant was determined in a Spinco model-*E* ultra-centrifuge at 56,100 r.p.m. The pattern obtained after a digestion period of 200 min. showed clearly the presence of light and heavy meromyosin, and was similar to that formed by tryptic digestion of the myosin solution with 0·04 mgm. crystalline trypsin for 10 min.[8].

The trypsin column described here may be of particular use in the degradation of peptides and proteins for amino-acid sequence analysis. Since the various lysyl and arginyl peptide bonds of proteins and peptides may differ in their susceptibility towards trypsin, it is possible that preferential hydrolysis might be achieved by varying the rate of flow of the substrate through the trypsin column. Finally, it is possible that the principle used for attaching the enzyme with the aid of linear polymeric chains to a water-insoluble carrier might be used for the preparation of other water-insoluble proteins with biological activity. In such cases it will be of primary importance to determine the functional groups which are non-essential for the activity, and to find the suitable chemical reactions for forming the desired biologically active water-insoluble products.

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PHYSIOLOGY

Phosphorylation as a Factor in promoting the Crabtree Effect in the Amytal Ascites Sarcoma of White Mice

CRABTREE[1] has demonstrated an inhibition of oxygen consumption in several different malignant tissues following the addition of glucose. Many attempts have since been made, especially during recent years, to explain the mechanism of this phenomenon. Certain workers[2,3] regard adenine nucleotides, others[4,5] inorganic phosphorus, as responsible for the production of the Crabtree effect and postulate a competition between the oxidative and glycolytic systems for one of these substances. Ács *et al.*[6] have suggested that a location of enzyme systems unique for the cells involved also plays some part in producing the inhibitory effect.

The hypothesis of a direct competition for adenosine diphosphate seems to be disproved by the experimental observation that the inhibitors of glycolysis do not counteract the Crabtree effect, although they completely stop the glycolytic phosphorylation of adenosine diphosphate. The significance of the role of inorganic phosphorus, on the other hand, seems to be substantiated by the experiments of Brin and McKee[4], who succeeded in partially arresting the Crabtree effect by raising the concentration of inorganic phosphorus to 55 m.moles/l.

Data are very scanty as regards changes in the level of inorganic phosphorus during the incubation of ascites cells with glucose, and even the available reports refer to cases observed in phosphate-buffered media[7].

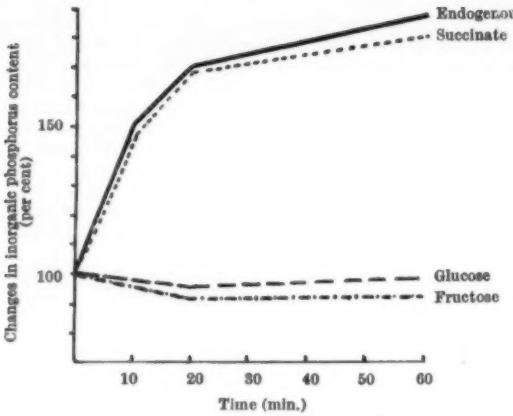

Fig. 1. Percentage changes in the inorganic phosphorus content of ascites cells in the course of incubation without substrate, with glucose (200 mgm. per cent), with fructose (200 mgm. per cent) and sodium succinate (0·02 *M*) regarding initial value as 100 per cent

We have studied changes in the inorganic phosphorus content of amytal ascites sarcoma cells occurring in the presence of different substrates without phosphate buffer. Incubation on endogenous substrate resulted in a significant increase of inorganic phosphorus; regarding the initial value as 100 per cent, it went up to 187 per cent within 1 hr., while the level of inorganic phosphorus decreased to 97 per cent in a medium containing 200 mgm. per cent of glucose. Fructose in a similar concentration is likewise capable of preventing the release of inorganic phosphorus, while both sodium succinate and sodium fumarate fail to prevent any effect (Fig. 1). This change in the level of inorganic phosphorus is not affected by the presence of either sodium fluoride or monoiodoacetic acid. Unlike glucose or fructose, fructose-1,6-diphosphate is unable to prevent the accumulation of inorganic phosphorus; this cannot be ascribed to a possible impermeability to phosphorylated sugars since similar results have been observed in homogenized systems as well. A typical change in inorganic phosphorus occurs if ascites cells are first incubated for an hour without substrate and glucose is added thereafter: inorganic phosphorus increases rapidly in the first phase, and drops to the initial level 10 min. after the addition of glucose (Fig. 2).

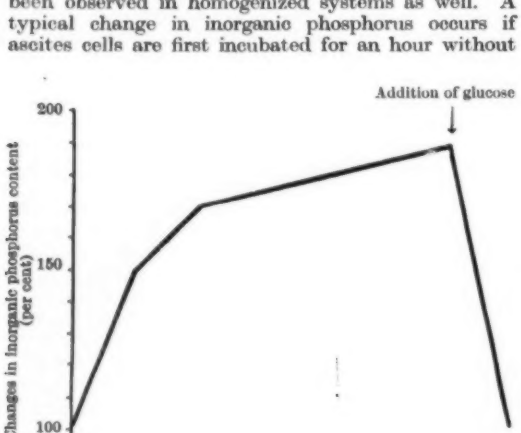

Fig. 2. Effect of glucose on changes in inorganic phosphorus contents of ascites cells. Glucose was added to cells after their incubation for an hour on endogenous substrate

All these observations substantiate the significance of phosphorylation as a factor responsible for the Crabtree effect. Phosphorylation and not complete decomposition of the sugars is necessary for the production of the effect, since—apart from glucose, fructose and mannose which undergo phosphorylation and metabolization—2-deoxy-D-glucose, too, is capable of provoking the Crabtree effect[7], although 2-deoxy-D-glucose undergoes phosphorylation without suffering complete breakdown. The role of phosphorylation is further emphasized by the fact that galactose, which gains access to the cells but undergoes no phosphorylation, fails to elicit the Crabtree effect[7]. Nor is it reduced by glucosone which, while being bound to the hexokinase of the Krebs-2 ascites cells, is phosphorylated only to a very moderate extent[5].

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New Evidence for a Cholinergic Process in Sympathetic Transmission

Recently a cholinergic mechanism has been proposed in sympathetic transmission[1–3]. This suggestion was based on the following pieces of evidence. Sympathetic nerves contain cholinergic fibres[2]. Acetylcholine can exert a sympathomimetic effect acting at sites beyond the sympathetic ganglion cell, and this action depends on the presence of a store of catecholamine in the peripheral tissue[4]. Larger doses of acetylcholine can block the response to stimulation of postganglionic sympathetic fibres[3]. It was visualized that acetylcholine liberated from the endings of the cholinergic sympathetic fibres would impinge on a store of noradrenaline in the vicinity of the effector cells to bring about a final adrenergic response.

MacIntosh, Birks and Sastry[5] have shown that the drug hemicholinium inhibits the synthesis of acetylcholine in brain tissue, and that this effect of hemicholinium produces failure at sites where acetylcholine is a neurohormone. Hemicholinium injection into animals caused death by respiratory paralysis, and other effects similar to those of tetanus and botulinum toxins[6]. The addition of hemicholinium to the fluid perfusing the cat's superior cervical ganglion led to failure of transmission and simultaneously the rate at which acetylcholine was released decreased[5]. Hemicholinium produced block at the neuromuscular junction and at parasympathetic nerve endings[5,7–9]. The action of hemicholinium in inhibiting acetylcholine synthesis could be reversed

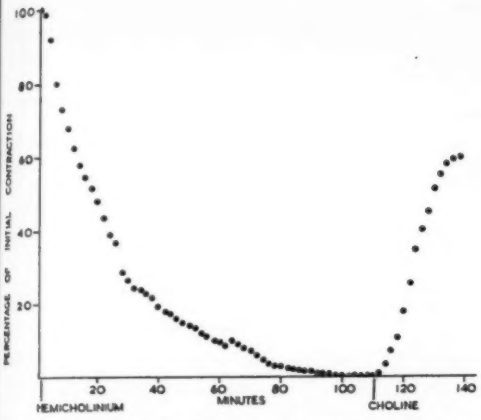

Fig. 1. Contractions of the guinea pig vas deferens in response to stimulation of the hypogastric nerve with 2-msec. pulses at 20/sec. for 10-sec. periods at 2-min. intervals. Each point is the mean of two-four experiments. After hemicholinium (20 μgm./ml.) the responses gradually decreased. The failure of transmission persisted after the bath was washed out at the 100th min. Choline (100 μgm./ml.) restored the response to nerve stimulation

by choline[5]. This finding could explain the effect of choline in restoring the response to nerve stimulation when hemicholinium had produced a failure of transmission[5–8].

We have investigated the effect of hemicholinium on the response to stimulation of a sympathetic nerve in order to test the proposal of Burn and Rand that a cholinergic process is involved in sympathetic transmission.

We chose for this investigation the isolated vas deferens of the guinea pig with the postganglion sympathetic hypogastric nerve attached. (This preparation was developed by Dr. S. Huković, working in the Department of Pharmacology, Oxford.) The vas deferens was suspended in an organ bath and the nerve stimulated with 2-msec. pulses at supramaximal strength for periods of 10 sec. every 2 min. The amplitude of the contraction of the vas deferens in response to nerve stimulation depended on the frequency of stimulation. With frequencies ranging from 7 to 20/sec., the response to successive periods of stimulation remained constant over long periods of time. A dose of tolazoline which specifically blocked the response to noradrenaline abolished the response to nerve stimulation. A dose of atropine which specifically blocked acetylcholine did not affect the response to nerve stimulation. Thus the hypogastric nerve to the vas deferens answers to the requirements of a sympathetic innervation.

When hemicholinium was added to the bath to make a concentration of 20 μgm./ml., the responses of the vas deferens to hypogastric stimulation gradually decreased and were finally abolished (Fig. 1). The rate at which the responses declined increased with increasing frequencies of stimulation. Previous observations that failure induced by hemicholinium depended on the frequency of stimulation have been reported for transmission in the superior cervical ganglion[5], and the neuromuscular junction[7,9].

Wilson and Long[9] have stated that hemicholinium is less active in blocking the response to nerve stimulation in sympathetically innervated structures than at parasympathetic nerve endings or at the myoneural junction. Their experiments were made on organs *in situ*, whereas our observations have been made on an isolated organ. In order to make a comparison between a sympathetically innervated structure and the myoneural junction, we have examined the isolated diaphragm innervated by the phrenic nerve taken from the guinea pig. In this preparation a higher concentration of hemicholinium (200 μgm./ml.) was required to produce a failure of transmission than was the case with the vas deferens. However, it is difficult to make comparisons because we observed again in this preparation that the rate at which failure was produced increased with increasing rates of stimulation. A further comparison of the action of hemicholinium on the response to nerve stimulation has been made in which we used a parasympathetically innervated structure. For this we used isolated rabbit atria with the vagus nerves attached[10]. Stimulation at 25 pulses/sec. applied to the vagi for periods of 1 min. duration at 4-min. intervals produced constant responses. After the addition of hemicholinium to the bath in a concentration of 40 μgm./ml., we observed a gradually developing decrease in the response to vagal stimulation, and the response was almost abolished by the fifth period of stimulation.

When the responses of the vas deferens or the diaphragm to stimulation of the appropriate nerve had been completely blocked by hemicholinium, they could be restored by the addition of choline (0·1–1·0 mgm./ml.) to the bath.

In our experiments we have shown that hemicholinium produced a failure of transmission at two sites in which it is not disputed that acetylcholine is a transmitter, namely, in the innervation of the diaphragm by the phrenic nerve, and in the innervation of the atria by the vagus. The effect of hemicholinium in producing a failure of transmission in the sympathetic innervation of the vas deferens has two features in common with its actions at cholinergic sites; the failure depends on the frequency of stimulation, and it is reversed by choline. Thus there is additional evidence for the hypothesis of Burn and Rand that there is a cholinergic process operating at sympathetic nerve endings.

We are indebted to Dr. J. P. Long of the Department of Pharmacology, State University of Iowa, Iowa City, U.S.A., for a generous gift of hemicholinium. This work was done while one of us (M. J. R.) held a fellowship of the Life Insurance Medical Research Fund of Australia and New Zealand.

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Histochemical Demonstration of the Mode of Action of the Alkaloid in Mussel Poisoning

It is generally accepted that the heat-resistant alkaloid which may be extracted from the digestive gland or liver of shellfish in coastal areas where poisoning of humans has occurred is responsible for the clinical picture in these cases. The same poison has been found in the dinoflagellate *Gonyaulax catenella*[1] on which the bivalves feed at certain times of the year, and the plankton has, therefore, been held responsible for the production of the toxin.

The exact mode of action and the nature of the poison are as yet unknown[2]. It is described as an alkaloid with muscarine-like actions[3], and is a potent neurotoxin, but, apart from the central and peripheral neurotoxic actions, Sapeika[2] has also described a direct depressant action of the toxin on the myocardium and its conducting tissues.

In the present investigation the small amount of mussel extract (2 c.c.) which was used was kindly supplied to us by Dr. N. Sapeika. The extract was prepared from uncooked black mussels according to Dack's[4] method.

On testing the extract, it was found that 0·6 mgm. injected intraperitoneally caused the death of rats weighing 70 gm. in a few minutes.

The extract contained 225 mgm. of the alkaloid per ml. Various dilutions of this extract were tested on 20-μ thick sections of cold, formalin-fixed rat brain and intercostal muscle. The acetylcholinesterase was demonstrated according to Gomori's[5] modification of the Koelle method. The sections were pre-incubated in toxin plus buffer for 1 hr. before being transferred to the same concentration of the toxin in the substrate mixture. Control sections were pre-incubated in buffer alone. The degree of inhibition obtained and the concentrations used are listed in Table 1. The caudate nucleus was used to assess acetylcholinesterase inhibition.

Table 1. Inhibitory Effect of Mussel Extract on Rat Brain and Intercostal Muscle

Concentration	mgm./ml.	Percentage inhibition
Rat brain		
0·1 ml. toxin/ml. substrate	22·5	100
0·07 " "	15·75	100
0·05 " "	11·25	100
0·04 " "	9	100
Motor endplates		
0·04 ml. toxin/ml. substrate	9	±10
0·027 " "	5·075	0
0·02 " "	4·5	0
0·016 " "	3·6	0

In the concentrations used only slight inhibition was observed in the very strong motor end-plate acetylcholinesterase activity; but, due to the small amount available, this could unfortunately not be tested in a higher concentration-range. However, total inhibition of acetylcholinesterase was produced in the caudate nucleus in the entire concentration-range of the toxin studied. At the same time, marked inhibition was also observed in the supra-optic neurones.

No inhibition of pseudocholinesterase could be seen in the capillary walls or myelinated areas[6].

From the above observations, it appears that the alkaloid has a very marked specific acetylcholinesterase inhibitory effect similar to some of the organo-phosphorus compounds. In view of this, it is suggested that future cases of poisoning be treated with one of the oximes such as pyridinealdoxime methiodide[7].

We are indebted to Dr. N. Sapeika for supplying us with the toxin and to Dr. R. Smit for advice.

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Nature of the Leucocytosis-inducing Factor in Plasma

It is now well known that fever[1] and leucocytosis[2], brought about by typhoid vaccine, are the result of the formation of at least two separate factors and not due to the direct action of vaccine (endotoxin) on the fever centre or on the bone marrow. Fukuda and Matsumoto[3] have recently demonstrated that the two factors act quite independently of each other and that in adrenalectomized animals, in particular, in spite of the normal occurrence of fever response due to the formation of the endogenous fever factor, leucocytosis fails to occur, and the leucocytosis-inducing factor cannot be detected by the use of passive transfer technique. The formation of the leucocytosis-inducing factor was found to depend solely on the presence of glycocorticoids. Moreover, the formation of this factor after the injection of vaccine could be inhibited by insulin administration, and conversely enhanced in an alloxan-diabetic state[4]. It was the object of the present work to examine whether or not this leucocytosis-inducing factor which is detectable in the circulating blood is identical with the 'leucocytosis-promoting factor' of Menkin[5] which was isolated from sterile exudates.

Typhoid–paratyphoid vaccine for clinical use (0·1 ml./kgm.) was first administered intravenously to a rabbit weighing about 2 kgm. At the time when a pronounced leucocytosis occurred (usually 8 hr. after), the animal was bled from the well-arterized ear vein (25 ml. in 10 min.) and serum was obtained. This serum was found to be capable of inducing a prompt rise in leucocyte counts (pseudo-eosinophilia) when given intravenously to a test rabbit (5 ml./kgm.). The promptness of the occurrence of leucocytosis without appreciable fever and preceding leucopænia is very characteristic and strongly suggests that this reaction differs greatly from the leucocytic response brought about by the vaccine itself or eventual pyrogenic contamination. The effectiveness of the leucocytosis-inducing factor did not diminish during dialysis through 'Cellophane' tubing against running tap water. Its activity was not reduced by heating at 57° C. for 30 min., but was completely lost at 100° C. within 30 min. The leucocytosis-inducing factor, like Menkin's leucocytosis-

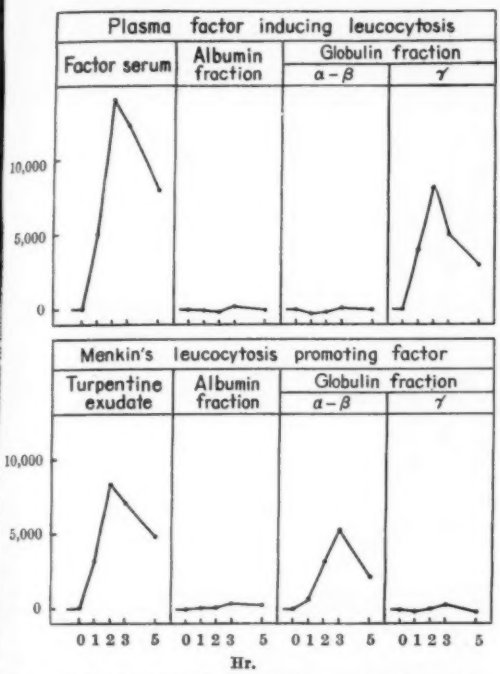

Fig. 1. Effective protein fraction of factor serum and turpentine exudate

promoting factor, is thus non-dialysable and thermolabile.

Next, protein fractions were prepared from the effective serum by the ordinary fractionation with ammonium sulphate and examined for their activity in inducing leucocytosis.

Each fraction, which had been dialysed and equilibrated with a physiological saline solution, was injected intravenously into test animals in an amount equivalent to 10 ml. of serum. As illustrated in Fig. 1, only a γ-globulin fraction precipitable by 35 per cent saturation of ammonium sulphate was found to be effective in producing the characteristic leucocytosis. This finding seemed to us very striking, for it has been reported that Menkin's leucocytosis-promoting factor is found in a pseudoglobulin fraction of the exudates[6], being distributed between α_1- and α_2-globulin[7].

For the sake of comparison, turpentine pleuritic exudate from rabbits which would contain Menkin's leucocytosis-promoting factor was also fractionated by the same method. The results of intravenous administration of each of the fractions corresponding to 5 ml. of the exudate (*p*H 7·4) are also given in Fig. 1. It will be seen that the activity is associated with the α- and β-globulin fractions, which are precipitable by 50 per cent saturation of ammonium sulphate. The pleuritic exudate from adrenalectomized animals was found to be also effective. The formation of Menkin's leucocytosis-promoting factor, therefore, does not appear to depend on the presence of glycocorticoids, forming a sharp contrast with the case of the leucocytosis-inducing factor.

It may therefore be concluded that there exist two distinct factors both responsible for the production of leucocytosis. One will be formed in the circulating blood in response to typho." vaccine or other pyrogenic large molecular substances, whereas the other is formed in inflammatory exudates by the injured cells, even in the absence of the adrenal. Although Menkin has expressed the opinion that the latter factor (leucocytosis-promoting factor) may enter the circulating blood stream and then comes to be responsible for the leucocytosis frequently associated with inflammatory processes, there is no likelihood that the leucocytosis-promoting factor enters the circulation in large quantities, except under conditions of stress such as epinephrine administration.

Details of the experiments concerning these problems will be published elsewhere.

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Importance of Insulin and of the Adrenal Cortex in determining the Toxicity in Baboons (*Papio ursinus*) of Human Anterior Pituitary

Growth hormone administered to normal, diabetic or hypophysectomized dogs produces severe toxic reactions which may terminate fatally[1]. Human anterior pituitary preparations may also precipitate severe toxic reactions in spontaneous human diabetes and mild reactions even in non-diabetics[2,3]. Similarly, saline suspensions of acetone-dried, human anterior pituitary lead to fatal reactions in insulin-deprived, depancreatized baboons[4]. Cortisone prevents the adverse reactions of growth hormone in hypophysectomized dogs[5], but not in diabetic baboons[4].

During the course of our investigations into the endocrine control of the metabolic disorder induced by complete pancreatectomy in the baboon, we had occasion to administer human anterior pituitary to 2 normal and 3 adrenalectomized baboons, and to 15 baboons either with the hypophysis or the adrenal removed in addition to the pancreas. Unlike the normal dog, the normal baboon fails to develop any gross clinical reactions if treated with ten times the amount of human anterior pituitary necessary to produce death in the insulin-deprived, depancreatized baboon. In the presence of an intact pancreas, human anterior pituitary is well tolerated by adrenalectomized baboons maintained with doca and/or hydrocortisone and by hypophysectomized baboons. Indeed, unlike the dog, human anterior pituitary greatly improves the physical state of the hypophysectomized baboon. Furthermore, although human anterior pituitary induces an intensely fatty liver in the diabetic baboon, provided sufficient insulin is administered, the animal remains well. Doubly operated, adrenalectomized-depancreatized baboons receiving doca but no insulin are unaffected by

human anterior pituitary. However, if the latter baboons, in addition to doca, also receive hydrocortisone, then severe toxic reactions manifest themselves within 10–12 hr. and these may prove fatal if human anterior pituitary is continued. Hypophysectomized-depancreatized baboons deprived of insulin may die rapidly after the injection of human anterior pituitary.

From these several experiments, it would appear that the toxic effects of human anterior pituitary depend primarily on an insufficiency of insulin and on the presence of at least some 11-oxycorticosteroids akin to cortisone or hydrocortisone. The fact that toxic reactions develop in hypophysectomized-depancreatized baboons deprived of insulin but receiving human anterior pituitary would indicate that the adrenal cortex of the hypophysectomized-depancreatized baboon continues to secrete 11-oxycorticosteroids, albeit in reduced amounts, for several months at least after hypophysectomy.

We wish to express our appreciation to Dr. J. Friedman, Department of Forensic Medicine, University of the Witwatersrand, and to Dr. M. Prates, director of Pathological Services of Mozambique, for making available the human pituitaries.

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Phosphate and Salt Uptake by Bakers' Yeast

Uptake of phosphate by *Saccharomyces cervisiae* has three components as indicated by first-order kinetic analysis of uptake under steady-state conditions as a function of phosphate concentration. Two of these components, having Michaelis–Menten constants $K_m = 10^{-5}$ and 10^{-3}, respectively, are evident on a plot of rate of uptake m against m/phosphate concentration[1] (Fig. 1). Action of glycolytic and respiration inhibitors, including anaerobiosis —illustrated by the action of iodoacetate (Fig. 1)— indicates that both these components are coupled to oxidative phosphorylation associated with the action of glyceraldehyde-3-phosphate dehydrogenase. The component reaction with $K_m = 10^{-5}$ is found to be rate-limited by formation of adenosine triphosphate, which acts as a competitive inhibitor in the oxidative phosphorylation, and the componert with $K_m = 10^{-3}$ by the action of hexokinase, which becomes rate-limiting for utilization of adenosine triphosphate. The coupling of phosphate uptake with glycolysis, but not its components, was recognized by Strickland[2] and Goodman and Rothstein[3]. Rothstein[4], in particular, has related the uptake to glycolytic activity at a membrane surface.

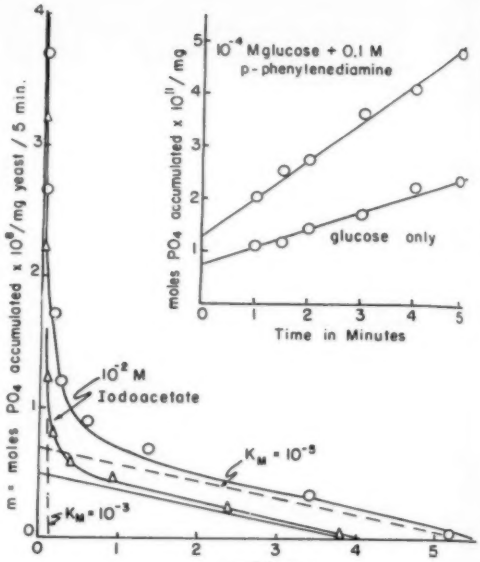
m = moles PO4 accumulated x 10^6/mg yeast / 5 min.
m x 10^6/(PO4)
10^-2 M Iodoacetate
K_M = 10^-5
K_M = 10^-3
10^-4 M glucose + 0.1 M p-phenylenediamine
glucose only
moles PO4 accumulated x 10^11/mg
Time in Minutes

Fig. 1. Hofstee graph for aerobic accumulation of phosphate at concentration of 10^{-3} to 10^{-6} M by bakers' yeast in the presence of 0·3 M glucose at pH 4·0

Fig. 2. Effect of 0·1 M p-phenylenediamine on aerobic phosphate accumulation by bakers' yeast from a 2×10^{-6} M solution in the presence of 10^{-4} M glucose

A third component of phosphate uptake having $K_m = 10^{-6}$ is observed with great consumption of oxygen when phosphate and glucose concentrations are low. It is responsive to respiration inhibitors (Fig. 2), increasing, for example, in the presence of p-phenylenediamine by increase of site with constant rate of turnover, and is found to be coupled to oxidative phosphorylation associated with oxidation of cytochrome b. The contribution of this component to uptake with phosphate concentrations greater than 10^{-5} M in the presence of glucose ($>0{\cdot}01$ M) is negligible. The conclusion is that in bakers' yeast the activity of the respiratory chain is coupled to only a minor extent to phosphate uptake at an external membrane surface.

That these observations are general for salt accumulation is indicated by rubidium uptake by bakers' yeast under aerobic and anaerobic conditions (Fig. 3). Anaerobiosis increases the concentration of sites without affecting rate of turnover.

Barley roots, in contrast to bakers' yeast, take up phosphate only under aerobic conditions. The sites of uptake in barley roots are associated with oxidative phosphorylation in the respiratory chain[5]. The mitochondria seem to be effective at a limiting membrane and simply might be embedded in that membrane. In bakers' yeast the respiratory chain, whatever its particulate nature, appears to be functioning inside the limiting membrane and acts in phosphate uptake chiefly as an oxidant for reduced diphosphopyridine nucleotide. Under anaerobic conditions the oxidation is chiefly accomplished by the action of alcohol dehydrogenase. Barley roots also form ethanol[6], but the triose phosphate dehydrogenase action utilizing oxidized diphosphopyridine nucleotide is internal to the cells and thus not anaerobically functional.

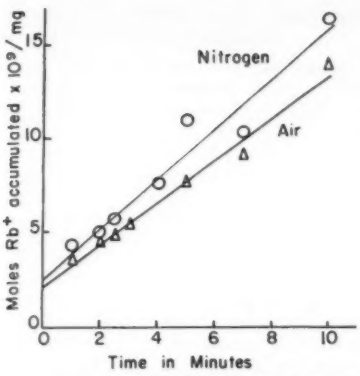

Fig. 3. Accumulation of rubidium ions by bakers' yeast from 10^{-4} *M* solution at pH 4·0 under aerobic and anaerobic conditions

The yeast cells used in this work were grown in pure culture, to eliminate a common and very troublesome bacterial contaminant, on beef extract peptone medium containing 0·15 *M* sodium chloride and with 0·3 *M* glucose as a substrate. The oxygen consumption was $2·3 \times 10^{-6}$ mole oxygen/mgm. dry weight. Cells were washed once with 0·15 *M* sodium chloride and introduced at zero time into a salt solution containing phosphorus-32 or rubidium-85. Uptake was terminated by centrifuging (10 sec.) and washing.

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HÆMATOLOGY

An Albumin Gradient Method for separating the Different White Cells of Blood, applied to the Concentration of Circulating Tumour Cells

The albumin sedimentation method of Vallee *et al.*[1] has been applied to the problem of isolating tumour cells from the circulating blood[2]. This method and its modifications involve the collection of the cells at an interface. When a variety of cells together with platelets are packed at an interface they are apt to sink or float as a unit. Such artefacts may seriously interfere with separation in a centrifugal field[3]. Moreover, we have found the cells to show morphological changes after prolonged centrifugation in contact with a foreign solution. It is therefore desirable to use a gradient method[4].

The present method avoids interfaces, dispenses with the necessity for making up solutions of accurately known specific gravity, and exposes the cells for the shortest possible time to the minimum possible concentration of foreign substances. The cells are suspended throughout in their own plasma.

16 ml. of venous blood is taken with a siliconed syringe into a siliconed vessel containing 4 ml. of 6 per cent dextran in saline ('Dextraven') with 40 mgm. of ethylenediamine tetraacetic acid dipotassium salt. A silicone rubber bung is inserted, and the contents mixed. The tube is stood for about ½ hr. until the red cells have sedimented. The supernatant plasma containing the white cells is removed and centrifuged at 1,000 r.p.m. for 10 min. The procedure so far is that of Alexander and Spriggs[5] except for the use of ethylenediamine tetraacetate instead of heparin in order to prevent platelet clumping. The deposit is resuspended in 0·5 ml. of its own plasma, and is referred to as the 'leucocyte suspension'. The supernatant plasma, which was poured off, is centrifuged again at 3,000 r.p.m. for 5 min. before being used in subsequent stages of the separation.

Bovine albumin solution is prepared as described by Roberts *et al.*[2]. We have used Armour's bovine plasma albumin (fraction V). The final concentration is immaterial provided that the solution has a higher density than the red cells; it should have a specific gravity 1·100 or above.

About 0·5 ml. of the albumin solution is placed in the bottom of a siliconed tube of 6 mm. bore, and an equal volume of the plasma is layered on top. Using a sealed-off Pasteur pipette (with an angle at the end) as a stirrer, the interface is broken, and the fluids are mixed by passing the stirrer up and down with gradually increasing amplitude, but avoiding the top and bottom of the column. A visible gradation in the colour of the column is used as a guide to the correct degree of mixing; the operation takes not more than 30 sec.

The white cell suspension is layered on to the column, and the tube is centrifuged for 15 min. at 3,000 r.p.m. By this time several layers have formed, as shown in Fig. 1.

The topmost layer consists of platelets with monocytes and some lymphocytes. This layer is often double, the upper part consisting almost entirely of platelets and the lower containing the mononuclear cells. Türk cells and any megakaryocytes which have retained their cytoplasm are also present in this layer.

Fig. 1

The plasma between layers *A* and *B* is often clear, but it may contain cells, particularly lymphocytes and myelocytes if present.

Layer *B* consists of the polymorphonuclear leucocytes. The basophils are commonest near the top and the eosinophils near the bottom, but they do not segregate from the neutrophils. Bare megakaryocyte nuclei are usually found in layer *B*.

Layer *C* consists of red cells. This layer may be translucent, owing to the high refractive index of the medium; the red cells are not in fact hæmolysed.

To find tumour cells, the whole of layer *A* together with all the fluid above it is pipetted off, diluted with plasma, and centrifuged until the cells are deposited. The deposit is then spread on slides, air-dried and stained with May–Grünwald and Giemsa. We have found that if a drop of the deposit from an

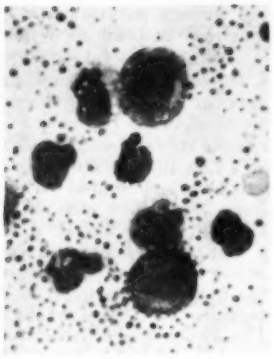

Fig. 2

effusion containing tumour cells is added to a 16-ml. sample of blood and processed by the above method, the tumour cells can be recovered from above the platelet layer, sometimes practically pure. They are also present in numbers in the platelet-monocyte layer (layer *A*), but very few sink below this.

Fig. 2 shows a film of layer *A* from a patient with reticulosarcoma whose direct blood film was normal. Besides monocytes and platelets, two reticulosarcoma cells are shown. The photograph demonstrates the good cell preservation and the absence of platelet agglutinates.

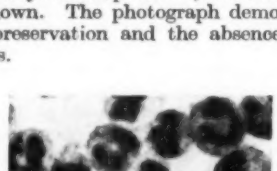

Fig. 3

Fig. 3 shows a film of the polymorphonuclear leucocyte layer (layer *B*); red cells are practically eliminated. This layer is not used in the examination for tumour cells; but the photograph shows that the same method would be useful for the preparation of polymorphonuclear leucocyte suspensions for other purposes.

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Properties of a Further Variant of Hæmoglobin M

Hæmoglobin M, discovered in 1948 by Hörlein and Weber[1], is an abnormal hæmoglobin of rare occurrence, three variants of which have since been identified[2,3]. In two members of a family of Leipzig, Germany—a child and his father, the former having been clinically studied, on account of congenital methæmoglobinæmia, by one of us[4]—we were able to demonstrate a new type of hæmoglobin M.

Absorption spectra of destromatized hæmolysates made from washed erythrocytes of the patient and a normal adult control are shown in Fig. 1. After conversion of the oxyhæmoglobin to methæmoglobin by means of potassium ferricyanide, an absorption band at about 600 mμ (contrary to methæmoglobin A) and an inflexion at 540 mμ (similar to methæmoglobin A) appeared in the spectrum of the patient's hæmolysate. No difference was observed in cyanmethæmoglobin spectra of both hæmolysates. Isolation of methæmoglobin M in a pure state from the patient's hæmolysate (= hæmoglobin A + M), using starch block electrophoresis at *p*H 7·0 according to Gerald and George[5], was not entirely satisfactory. A brown front and a slower portion of grey-green colour appeared in the otherwise unseparated spot. On elution, the grey-green portion spectrophotometrically showed an intensified absorption band near 600 mμ and a more distinct inflexion at 540 mμ. However, an inflexion in the region 640–620 mμ indicated that separation from methæmoglobin A had not been complete. On the evidence that 20–25 per cent of the patient's hæmoglobin is of type M (see below), the spectrum of 'pure' methæmoglobin M was calculated from the data of the patient's and a normal adult's methæmoglobin spectra (Fig. 1): there is a rather prominent peak at 602 mμ and a second absorption band at 540 mμ, the inflexion around 630 mμ being practically straightened.

Reaction of potassium cyanide ($1{\cdot}45 \times 10^{-2}\,M$) and methæmoglobin A + M ($1{\cdot}35 \times 10^{-5}\,M$) proceeded in two phases when followed at 630 mμ, *p*H 6·8: a very rapid one, identical with the reaction of methæmoglobin A, and a slow one (Fig. 2). At

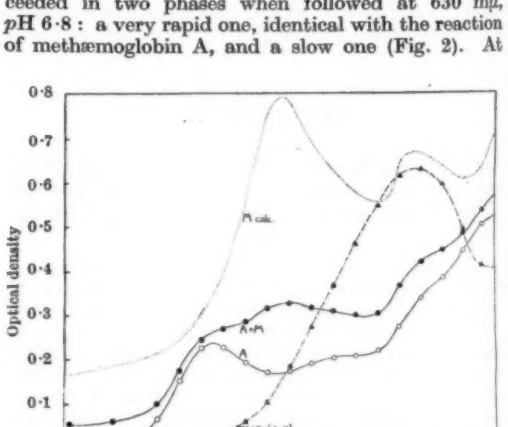

Fig. 1. Methæmoglobin absorption spectra of destromatized hæmolysates of the patient (A + M, ●) and a normal adult (A, ○). ▲, Cyanmethæmoglobin (identical for A and A + M); ....., 'pure' methæmoglobin M calculated from A + M and A, assuming that 25 per cent of hæmoglobin M are present in A + M. Hæmoglobin concentration: 92 mgm./100 ml. = $1{\cdot}38 \times 10^{-5}\,M$, *p*H 6·8 (phosphate)

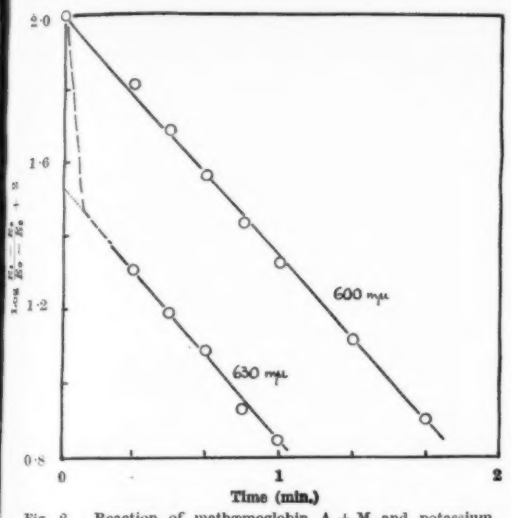

Fig. 2. Reaction of methæmoglobin A + M and potassium cyanide followed at 600 mμ and at 630 mμ

600 mμ only a slow reaction was demonstrable, its half-time being 27·5 sec. under the above conditions. From the data of Fig. 1 it is evident that at 630 mμ the combined reactions of both methæmoglobins and cyanide will be measured, whereas at 600 mμ—near the isosbestic point of methæmoglobin A and cyanmethæmoglobin—the reaction of methæmoglobin A is optically eliminated, leaving cyanide combination of methæmoglobin M open to analysis. By calculating the amount of methæmoglobin A which corresponds to the reduction in optical density at 630 mμ in the rapid first phase of cyanide combination, it was estimated that 79·5 per cent of methæmoglobin A and 20·5 per cent of methæmoglobin M should be present in the patient's erythrocytes. Reaction velocity of cyanide combination of methæmoglobin M at *p*H 6·8 was found to be less than 1/100, as compared with normal adult methæmoglobin under appropriate conditions (cyanide $4{\cdot}33 \times 10^{-4}$ *M*; methæmoglobin $1{\cdot}41 \times 10^{-5}$ *M*).

Oxidation of hæmoglobin M-containing oxyhæmoglobin solutions with potassium ferricyanide at *p*H 6·8 also proceeded in two phases, a rather rapid one and a slow one, the reaction velocity of the latter corresponding to the oxidation velocity of oxyhæmoglobin A. Similarly, comparative spontaneous oxidation of oxyhæmoglobin in patient's and normal adult's hæmolysates at room temperature, *p*H 6·8, showed distinctly more rapid oxidation (reaction velocities 1 : 23) of oxyhæmoglobin M. Evaluation of the experimental data confirmed that hæmoglobin M-content of the patient's hæmolysate was about 23 per cent, which is in good agreement with the finding reported above.

The spectral characteristics of the methæmoglobin M described here are distinct from those of hæmoglobin M_B of Gerald and George[2] and hæmoglobin M_M of Pisciotta *et al.*[3]. Absorption bands near 600 mμ and 540 mμ are comparable to the findings of Gerald and George[2] in hæmoglobin M_S. In contrast, hæmoglobin M_S reacts rapidly with cyanide whereas this hæmoglobin M reacts slowly.

In view of the spectrophotometric and reaction characteristics, it seems justified to assume that the type of hæmoglobin M described here is essentially different from hæmoglobin M_S, hæmoglobin M_B, and hæmoglobin M_M. Following the general practice, we propose to designate it 'HbM_L' after the place of its origin. Spectral properties suggest that this type of hæmoglobin M might be the same as the one previously studied by Hörlein and Weber[1], and Heck and Wolf[5]. It is to be noted that in the latter a rapid spontaneous oxidation has been demonstrated by Kiese *et al.*[6].

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Difference between γ-Globulins fixed on the Platelets of Patients with Idiopathic Thrombocytopenic Purpura and of those suffering from Disseminated Lupus Erythematosus or a Panhæmatocytopenia

The direct antiglobulin consumption test using leucocytes or platelets[1] is based on the indirect antiglobulin consumption test[2,3]. It has been found to give positive results with both leucocytes and platelets from about 90 per cent of patients with disseminated lupus erythematosus and 30 per cent of cases of idiopathic panhæmatocytopenia, but with platelets only from approximately 65 per cent of cases of idiopathic thrombocytopenia[4].

It will be seen from Table 1 that when two different batches of anti-human-globulin serum (or Coombs's serum) were used, different results were obtained. Consumption of the anti-human-globulin serum was measured by testing against red cells sensitized with incomplete anti-D serum. It was found that whereas anti-human-globulin serum No. 1 was absorbed by the platelets of all three groups of patients, anti-human-globulin serum No. 2 was absorbed by the platelets of those suffering from disseminated lupus erythematosus or panhæmatocytopenia, but not of those with idiopathic thrombocytopenic purpura.

Table 1

No. of cases		Anti-human-globulin No. 1 incubated with		Anti-human-globulin No. 2 incubated with	
		Leucocytes	Platelets	Leucocytes	Platelets
4	Normal, negative controls	−	−	−	−
2	D.L.E.	+	+	+	+
5	Panhæmatocytopenia	+	+	+	+
6	Idiopathic thrombocytopenic purpura	−	+	−	−

+, Anti-human-globulin consumption; −, no anti-human-globulin consumption. D.L.E., disseminated lupus erythematosus.

The results obtained using anti-human-globulin serum No. 1 showed that γ-globulin had been fixed on the platelets of all three groups of patients. Using anti-human-globulin serum No. 2 it was shown that the antigenic structure of the γ-globulin fixed on the platelets of patients with idiopathic thrombocytopenic purpura was different from that on the platelets of patients in the other two groups. If we assume that the γ-globulin attached to the platelets is an auto-antibody, then these results would seem to show that there are two varieties of anti-platelet auto-antibodies.

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PATHOLOGY

An Oncolytic Virus recovered from Swiss Mice during Passage of an Ascites Tumour

The recovery of a tumour-destroying virus from mouse ascites was recently reported by Bennette[1]. It was serially transmissible and seemingly non-pathogenic in the absence of neoplastic cells. Filtrates of ascitic fluids and extracts of cells which harboured the contaminant were highly destructive for the Ehrlich carcinoma and also five other tumours.

An agent with strikingly similar properties has been under observation in our laboratories for the past two years. The effects of this agent were first observed by one of us (G. S. T.) in Swiss *W* mice following long-continued passage of the mouse ascites tumour described by Nelson[2] in 1956. A number of sub-lines, maintained by intraperitoneal injection, were lost after the sudden appearance of abnormal ascitic fluid and aggregates of the tumour cells. Bacteriological findings were negative and a virus was indicated by passage of the active agent through Coors filters (No. 3). Most of the following observations were based, however, on the use of abnormal fluids sedimented at low speed to remove the tumour cells.

In practice, 12–15 gm. weanlings from the random-bred specific pathogen-free colony of Swiss mice maintained at the Rockefeller Institute were used. They were injected intraperitoneally in groups of 5 with 0·1 ml. of normal tumour fluid diluted 1 : 5 and the same volume of cell-free fluid containing the contaminant. The mice were usually killed on the seventh day after injection. Those which received the virus in high concentration were either normal at autopsy or showed a slight reaction. Suppression of the neoplastic cells in the peritoneal cavity was essentially complete. In some cases a solid tumour arose at the site of injection in mice held for a longer time. Injection of the virus in low concentration, declining activity being retained up to a dilution of 10^{-6}, usually resulted in an irregular tumour growth. It was characterized by watery ascitic fluid with a reduced cell content and the appearance of a white membrane composed of aggregated cells, fibrin and debris. The membrane was generally attached to the liver but less regularly extended downwards into the folds of the intestinal tract, with resultant binding and distension. During life, this reaction was accompanied by abdominal swelling and either rectal soilage or plugging. Most of the mice were otherwise normal, but an occasional animal showed external or internal signs of jaundice, yellow ascitic fluid, and yellow or white foci of necrosis in the liver.

Our observations were limited to the one tumour. In the presence of uncontaminated ascitic fluid, the virus was passaged intraperitoneally more than fifty times with similar findings. It was active in mature mice as well as in weanlings, but had little or no suppressing effect on solid tumours produced by intramuscular injection. The virus was tested in three additional mouse strains and showed no evidence of host specificity. It was recoverable from the livers of injected mice and readily maintained by intraperitoneal passage of liver suspensions. In the absence of tumour cells, it produced no detectable reaction in weanlings but continued to multiply in the liver. Phase microscopy revealed dense circular inclusions in the cytoplasm of some tumour cells from abnormal fluids. Electron micrographs, made with the co-operation of Dr. Man-Chiang Niu, showed single or multiple cytoplasmic nests of circular or elliptical particles with maximum diameters of 50–70 millimicrons.

Bennette[1] stated that his virus was not pathogenic in the absence of tumour cells, but his observations were limited to weaned mice. Our virus was similarly inactive in weanlings, but was highly pathogenic for nurslings 1–2 days old. Intraperitoneal injection of contaminated cell-free fluid was attended by high mortality (78 per cent of 42 mice) between the fifth and the thirteenth day. Mice that survived through the ninth day were under-developed and stunted. Some of them showed oily coats, with or without rectal soilage, and yellow or white necrotic foci in the liver. External and internal signs of jaundice were occasionally noted. Oral administration of the virus resulted in similar findings. Liver suspensions from the infected nurslings suppressed growth of the ascites tumour on combined injection in weaned mice.

The oncolytic virus was also recovered from a few mice during a minor outbreak of intestinal disease which occurred during the early development of the specific pathogen-free colony. The rigid quarantine observed in the maintenance of this colony precluded introduction of the virus by accidental contamination with experimental wastes. Outward signs of the naturally acquired disease were limited to nurslings and were similar to those induced by injection. Oily coats and yellow foci in the liver were again observed. Several female breeders which were nursing infected young but were normal in appearance also showed focal involvement of the liver at autopsy. The virus was demonstrable on combined injection in weanlings.

When first observed, it was thought that the oncolytic agent might be a member of the hepato-encephalitis group of murine viruses. The recovery of murine hepatitis virus from the same ascites tumour after prolonged passage in Princeton mice was reported by one of us (J. B. N.)[3] in 1959. This relation was soon ruled out, however, by distinct behavioural differences. The intestinal and hepatic manifestations in nurslings were strongly suggestive of those produced by the hepato-encephalomyelitis

virus described in 1953 by Stanley, Dorman and Ponsford[4,5] in Australia. Oily coats and yellow foci in the liver were characteristic features. The neurotropic properties of their virus were brought out by serial passage. The cerebral behaviour of our virus has not been fully studied. It seems probable that the Australian, British and American viruses are interrelated and are widely distributed in mouse colonies as latent invaders. Direct comparison of the three agents is clearly indicated.

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Griseofulvin and Colchicine: Lack of Carcinogenic Action

DURING the investigation of the toxicology of griseofulvin, it was shown[1] that the antibiotic when given parenterally is a mitotic poison, in some respects similar to colchicine. Clinical investigation[2,3] showed that this did not represent an acute toxic hazard in clinical use. Nevertheless, interference with mitosis seems to us to imply a greater possibility of carcinogenic action on long-term administration than is the case with compounds devoid of this property. Colchicine has not yet been studied adequately from this point of view, and it was decided to include a group treated with this drug in a study of the long-term effects of griseofulvin.

Four groups of albino, Wistar rats were used. All were newly weaned at the commencement of the experiment. Group I received colchicine, 0·5 mgm./kgm., twice weekly for 42 weeks. The colchicine was initially given subcutaneously in saline, but because of local necrosis the vehicle was changed to arachis oil after four weeks. Group II received saline and arachis oil as controls to Group I. Group III received a finely ball-milled suspension of griseofulvin as a 10 per cent w/v dispersion in 0·5 per cent aqueous mixture of 'Dispersol *LN*' and 'Dispersol *OG*', at a level of 200 mgm./kgm., twice weekly by intraperitoneal injection for 93 weeks. Group IV received the suspending agents alone as a control to Group III. Each group comprised 10 male and 10 female animals.

Colchicine proved toxic in the initial stages, but griseofulvin was well tolerated until the seventy-fifth week of the experiment when mortality began to mount. At the end of 52 weeks dosing, eight animals treated with colchicine, but only two treated with griseofulvin, had died. At the end of 78 weeks experiment, nine animals of each group treated with the drugs had died. Five animals given colchicine and seven given griseofulvin survived until the experiment was terminated at the end of the ninety-third week.

All animals were examined after death for the presence of tumours and, unless postmortem autolysis was advanced, blocks of all the major organs were fixed for histological examination. The following tumours were encountered: Group I: colchicine treatment; one fibroadenoma of mammary gland; Group II: control to colchicine, four adenomata of thyroid; one leiomyosarcoma of the vagina and one sarcoma at injection site; Group III: griseofulvin treatment, one adenocarcinoma of cervix uteri; Group IV: control to griseofulvin, one interstitial cell tumour of the testis.

In the animals treated with either griseofulvin or colchicine, the nuclei of the liver and stomach mucosa of some appeared rather more variable in size than is normally the case. Other pathological changes were found equally in control and treated groups.

Although the numbers in these experiments are relatively small, it is clear that neither griseofulvin nor colchicine is a potent carcinogen, and indeed these experiments give no evidence of carcinogenic action of any sort of either compound.

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The Hedgehog as a Source of Human Ringworm

THE dermatophyte *Trichophyton mentagrophytes* has been isolated from a variety of animals, but although Georg[1] lists 18 wild and domestic mammals living in different geographical areas which are known to be spontaneous carriers of this pathogen, the hedgehog does not appear to have been included in any survey.

During March 1960 an adult female patient attended the mycological diagnostic clinic attached to this Department, complaining of ringworm, which she stated to have been contracted from a pet hedgehog. On examination, several raised itchy lesions were found, from which a pathogenic fungus was isolated. This was readily assigned to the genus *Trichophyton*, but less readily placed in a definite species. During the same month a similar isolate was obtained from a lesion on the wrist of an adult male, who had recently returned from a country holiday.

A series of 26 living and dead hedgehogs, collected in this area, were examined for the presence of a pathogenic fungus. Isolates of *Trichophyton*, similar in macroscopic and microscopic characters, were recovered from 7 (27 per cent) of the animals. Positive cultures were obtained from the quills of 4 and from the hair on the ventral body wall, the head or the ears of a further three. A hedgehog isolate (*H*1) was sent to Dr. Lucille Georg, Communicable Diseases Centre, Georgia, United States, who kindly identified it as *Trichophyton mentagrophytes*.

Mycelial fragments taken from the *H*1 strain were applied to an area of scarified skin on a guinea pig

and on a human volunteer. Rapidly spreading itching lesions were produced in both from which were recovered isolates identical with the *H*1 strain.

Hedgehogs were first introduced into the Dunedin district in 1885[2]. Several further liberations were made in both islands of New Zealand, and these mammals have become very numerous in several areas. Their contact with man and his domestic animals may be greater than is generally realized, and there seems to be good evidence that the dermatophyte strains which they carry are transmissible to man. They appear to constitute a hitherto unrecognized source of human infections.

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BIOLOGY

A Pacific Salmon (*Oncorhynchus gorbuscha*) in Scottish Waters

On July 16, 1960, in a salmon bagnet at Altens fishing station on the sea-coast near Aberdeen, a fish was caught which was recognized as unusual. It was sent to the Freshwater Fisheries Laboratory at Pitlochry and then to the British Museum (Natural History), where it was identified as *Oncorhynchus gorbuscha* (Walbaum)[1,2], the pink or humpback salmon, a species the natural distribution of which is along the Pacific coasts of North America and Asia from the Bering Straits to Peter the Great Bay and the Sacramento River.

This fish was 20¼ in. in overall length with a standard length of about 450 mm., a depth of 135 mm., a width of 67·5 mm., and a weight of 4 lb. 2 oz. It is at once recognizable as distinct from either *Salmo salar* or *S. trutta* by the deeper body, more pointed snout and the presence of coarse oval black spots on the caudal fin; it differs from these and *S. gairdnerii* (the rainbow trout) in the higher number of rays in the anal fin (*A* 17 as against 9–12, rarely 13 in *Salmo*) and of gill-rakers (26 on the whole of the first arch as against 24 or fewer in *Salmo*).

The scales, which are more numerous than in other species of *Oncorhynchus*—we counted approximately 170–174 in the lateral line—agree very well in structure with those of *O. gorbuscha* figured by Gilbert[3] and Davidson[4], showing one winter band only and the inner circuli not crowded as in the typical freshwater parr-life of *Salmo*. The humpback's life-history is well known[1,3–5]. It spawns in autumn (August–September in the River Amur). The eggs hatch in December, and the fry make their way to the sea as soon as they can swim, from April until June, at a length of 3·2–3·6 cm. They feed at first in water still brackish from the influence of the rivers (a phase consonant with the appearance of the first summer's growth of the scale) and then, at a length of 4–12 cm., move off to the open sea. Sexual maturity occurs at the end of the second year of life and no older fish have been caught in the spawning runs. Neither has any yearling fish been caught in fresh waters. Marking experiments indicate a high percentage of returns to the natal stream, but some straying may occur if suitable rivers enter the sea in the neighbourhood of the natal stream[4].

The Aberdeen fish, a male with enlarged testes, had the typical form and colouring of a 'clean' fish, with spots on the caudal fin only and none on the back, and without the kype and hump that develop at the spawning period. It is in the British Museum (Natural History).

We understand that, since 1956, the Russians have transferred very large numbers of Pacific salmon eggs, chiefly pink salmon, from Sakhalin Island north of Japan to the rivers of the Kola Peninsula. Up to the middle of September, they have had records of the return of some 75,000 fish to the rivers of the Kola Peninsula. There have also been reports of recaptures on the Norwegian coast, chiefly in the north, but extending as far south as Bergen, and in Iceland. Several thousand Pacific salmon have been caught on the Norwegian coast, though in Iceland the catches have been much smaller; probably less than fifty having been caught. It is, therefore, reasonable to assume that the pink salmon caught at Altens originated from one of the rivers of the Kola Peninsula.

We are grateful to Mr. G. G. J. Smart, of Messrs. Jos. Johnston and Sons, Ltd., of Montrose, for sending this fish caught in his firm's nets, to Mr. F. T. K. Pentelow (Ministry of Agriculture, Fisheries and Food) for helping to interpret the scales, and to Prof. G. V. Nikolsky and Dr. L. Rosseland for the information about catches in the U.S.S.R. and Norway respectively.

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Interspecific Hybrids of *Tilapia*

Whitehead's claim[1] to describe hybrids between *Tilapia nigra* and *T. zillii* in two waters in which both species had been introduced could be accepted only if supported by unequivocal evidence. His only evidence that *T. zillii* was one of the parents of the problematical fishes is that this was the only species other than *T. nigra* known to be introduced. We know enough of stocking accidents to place no reliance on this, especially when, as in this case, all the evidence points in another direction.

We have had the opportunity of studying Whitehead's fuller report, which he sent to one of us for criticism. From this we see that his statement[1] that "in most anatomical characters the hybrids resembled *T. nigra*" is true, but it would be better to say that these were characters of the section of the genus including *T. nigra* but not *T. zillii*. The divergences

from *T. nigra* are not in the direction of *T. zillii*. The body- and fin-colours[1] are in fact reminiscent of *T. leucosticta*, a mouth-brooding species which is an inhabitant of Lake Albert, the source of the East African stocks of *T. zillii*, and is known[2] to have been distributed with the latter in many East African waters from ponds at Kisumu. The toothed lower pharyngeal bone of the 'hybrid' is figured in Whitehead's full report, and he notes its resemblance to that figured for *T. leucosticta*[3]. The gill-rakers on the lower part of the anterior arch are 8–12 in *T. zillii*, 15–20 in *T. nigra*, 18–22 in the 'hybrids', 19–24 in *T. leucosticta*. The dorsal spines are 14–16 in *T. zillii*, 17–19 in *T. nigra*, 15–18 in the 'hybrids' and in *T. leucosticta*[3].

Whitehead's claim to have effected the cross *T. zillii* × *T. nigra* in a pond rests on the presence there after six weeks of a female carrying eggs in the mouth, and this is not adequate evidence.

We suggest that many of the supposed hybrids were *T. leucosticta*—individuals inadvertently introduced with *T. zillii* or their progeny. It would be less surprising if some hybridization should occur between these and *T. nigra*, and some of the problematical fishes need re-examination with this possibility in mind, as Mr. Whitehead now agrees in correspondence with us.

Since we wrote the above, we have examined one of the 'hybrids' from Tebere ponds and find it indistinguishable from *T. leucosticta*.

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Aquarium Behaviour and Breeding of *Hymenochirus*

Hymenochirus[1] is a genus of West African clawed aquatic toads which are considered to be closely related to *Xenopus*. In fact its members were originally described as belonging to the genus *Xenopus*[2].

Two years ago we were by chance able to obtain 15 young specimens of *Hymenochirus boettgeri* (Torn.) from a German importer of pet fishes, who had offered "afrikanische Kleinfrösche". As it turned out that nothing is known about the biology of this toad and that, so far as we can find, neither the breeding habits nor even the larvæ have hitherto been described, we decided to study the aquarium behaviour of the toads instead of using them for tissue preparations.

Hymenochirus is a true aquatic toad, and in spite of the fact that it moves, with jumps, much more easily on dry land than does *Xenopus* it has never been possible to find a toad on the terrestrial part of the aquarium. There are no external sex differences in the genital region but the females are usually identified through their broad body form. The toads are apparently exclusively carnivorous and feed willingly on *Tubifex* worms, *Daphnia* and various kinds of gnat larvæ, but also on different kinds of 'dead' food such as raw fish meat. The prey is obviously discovered and caught mainly with the aid of sight.

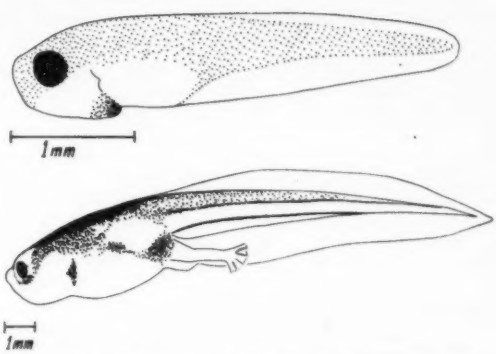

Fig. 1. Tadpoles of *Hymenochirus boettgeri*. The upper specimen is newly hatched, the lower one is 14 days old

A vibration sound, which recalls that of *Xenopus*, is produced by the *Hymenochirus* males. In this case, however, short croaking periods alternate with silent periods. Each croaking interval terminates with a sudden rise in the pitch of the voice.

The males are often seen clasping females as well as other males in the typical *Xenopus* manner. Two attempts were made to induce spermiation and ovulation with luteinizing gonadotrophin, but without success. However, a sunny position of the aquarium has recently been sufficient to induce the spawning act, which has taken place during the night hours in a slightly alkaline water at 23–24° C.

Copulation is performed in a very peculiar manner. It occurs at the surface, usually in connexion with an inhalation of air, and starts with the female turning upside down with the male still clinging to her back. Her genital tract is now kept slightly protruding above the surface of the water and 2–10 eggs are deposited. After this process the couple return to the bottom. The surfacing is repeated about every second minute until the ovaries are apparently exhausted after about fifty times.

The eggs float on the surface but they do not stick together. They are about 0·9 mm. in diameter, with jelly about 1·5 mm. The larvæ hatch after 2 days at a length of 3·2–3·5 mm. and are already pronouncedly pigmented at this stage. On the fourth day they start feeding on small aquatic animals, and much to our astonishment they took exclusively to a carnivorous diet during the whole larval period. Consequently the tadpoles of *Hymenochirus* are quite unlike those of *Xenopus* in this respect; they are unlike them in several other respects also. The filtering apparatus and the tentacles are omitted, they do not rest in the water in the typical oblique position, and the whole appearance is very fish-like.

It is clear that a study of the larval and adult biology of *Hymenochirus boettgeri* discloses a number of interesting differences between this species and *Xenopus laevis*. The adaptational and taxonomical significances of these diversities between the two genera of African pipide toads are under consideration.

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Akinetoplastic Strain of *Trypanosoma evansi* produced by 'Prothidium'

Since Werbitzki's[1] observations that organic dyes having Ehrlich's orthoquinoid constitution caused disappearance of the kinetoplast in trypanosomes, several workers have, from time to time, reported the occurrence of both spontaneous and chemically induced strains of akinetoplastic *T. evansi*. Hoare[2] has fully discussed the early literature on the subject. Recently, Muhlpfordt[3] has published his observations on the effect of trypaflavin on the kinetoplast of various trypanosomes, and has shown that repeated administration of trypaflavin caused the complete disappearance of kinetoplast in *T. evansi* in 81 days. With other trypanosomes such as *T. equiperdum*, *T. brucei* and *T. gambiense* it took 54, 121 and 122 days, respectively, for the complete disappearance of this organelle.

Hoare and Bennett[4] in 1938 showed that both spontaneous and induced akinetoplastic strains of *T. evansi* behaved like the normal ones, and that the absence of kinetoplast did not in any way alter the vital functions of the trypanosomes.

We have observed: (1) the quick disappearance of the kinetoplast from the otherwise normal strain of *T. evansi* as a result of treatment with a phenanthridinium compound 'Prothidium'; and (2) some apparent change in the functional activity of the akinetoplastic 'Prothidium'-treated strain.

The chemical composition of 'Prothidium' (Boots) is 2-amino-7-(2-amino-6-methyl-4 pyrimidylamino)-9-amino-phenyl-phenanthridine : 10 : 1-dimetho-bromide. 0·5 ml. of a freshly made 0·015 per cent solution of this drug was given subcutaneously to white rats weighing 100–125 gm. and showing a fair number of trypanosomes in the peripheral circulation. Three sets of experiments were carried out with two rats in each set. The ratio of kinetoplastic to akinetoplastic trypanosomes was estimated by counting a hundred trypanosomes in a stained smear made from one of the rats in each series. The akinetoplastic 'Prothidium'-treated strain is now being maintained in this laboratory and its functional behaviour so far observed (up to its 8th passage in rats) is reported as follows.

From Table 1 it will be seen that there was complete disappearance of the kinetoplast 44–60 hr. after treatment with the drug.

Table 1. Percentage of Kinetoplastic (*K*) and Akinetoplastic (*AK*) Trypanosomes at Different Hours

	18 hr.	44 hr.	60 hr.
Series I	*K*.28 : *AK* 72	All akinetoplastic	All akinetoplastic trypanosomes disappeared*
Series II	*K*.42 : *AK* 58	*K*.17 : *AK* 83	
Series III	*K*.34 : *AK* 66	*K*.20 : *AK* 80	

* There was a relapse after 30 days when only *AK* forms were seen.

The akinetoplastic strain thus obtained was found to breed true when passaged through rats. Table 2 shows an alteration in the functional activity of the akinetoplastic 'Prothidium'-treated strain as compared to the normal.

From Table 2 it is apparent that the akinetoplastic trypanosomes multiply less rapidly than the normal strain, and this leads to longer survival after infection. Ultimately, however, the host succumbs to infection with the same clinical and pathological picture as seen in rats infected with a normal strain of *T. evansi*. This akinetoplastic strain is now in its 8th passage, and the results are awaited with regard to its course of infection in larger animals (dog and horse).

Table 2. Prepatent and Survival Periods of Rats Infected with Normal and 'Prothidium'-treated Strain of *T. evansi*

	Normal strain	'Prothidium'-treated strain
Incubation period in days in six rats	2, 2, 2, 2, 3, 3	5, 5, 6, 9, 12, 12
Survival time in days after first appearance of trypanosomes	3, 3, 3, 4, 3, 4	3, 5, 8, 9, 12, 12

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Studies on Phycobilin Formation with Mutants of *Cyanidium caldarium*

Variously pigmented mutants of *Cyanidium caldarium*, an organism classified in succession as a blue-green, green, and red alga by Hirose[1] and which Allen[2] regards as an anomalously pigmented chlorophyte, appear to be excellent experimental materials for study of the synthesis of phycocyanin.

Pigment analysis of light-grown wild-type *C. caldarium* confirmed Allen's[2] report of the presence of chlorophyll *a*, carotenoid, and phycocyanin in this organism. In addition, allophycocyanin was found to be present. Absorption spectra of the extracted pigments are shown in Fig. 1. Dark-grown wild-type cells, unlike those reported by Allen[2], have been found to yield measurable amounts of chlorophyll *a* as well as carotenoid. As in the work reported by Allen[2] no phycobilins have been found in dark-grown wild-type cells. Mutant forms were obtained by exposure of wild-type or mutant cells to ultra-violet light. Absorption spectra of whole-cell suspensions of the wild and mutant types are shown in Fig. 2. Solutions of individual pigments were obtained as follows: (*a*) Cells were broken by grinding with polishing alumina or by means of a 10 kc./s. Raytheon sonic oscillator. (*b*) The chlorophyll and carotenoid pigments were then extracted in methanol and petroleum ether and separated on a sugar column developed with petroleum ether and *n*-propanol after the method described by Strain[3]. (*c*) The water-soluble phycobilins were separated on a calcium phosphate column[4] developed with 0·06 *M* sodium phosphate. Absorption spectra of extracted pigments and whole-cell suspensions were determined with a Cary recording spectrophotometer, model No. 11. The opal glass procedure of Shibata *et al.*[5] was used for the determination of absorption spectra of suspensions of intact cells. The organisms were grown at room temperature or at 43° C. on a medium similar to that used by Allen[2], to which 1 per cent glucose was added.

Four general types of variant forms have been found.

(1) *Dark-greening mutants.* Cultures of wild-type cells grown in darkness are yellow; carotenoid and traces of chlorophyll are detectable spectrophoto-

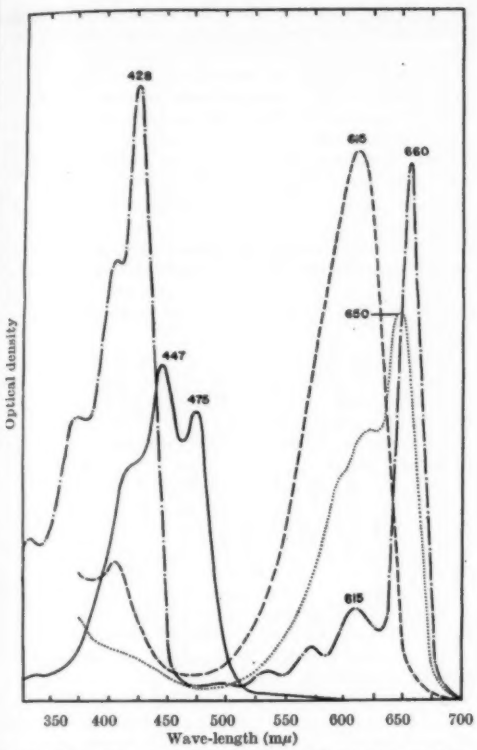

Fig. 1. Absorption spectra of pigments of wild-type *Cyanidium caldarium*. (Chlorophyll *a* and carotenoid in petroleum ether; phycobilins in water.) —·—, Chlorophyll *a*; – – –, phycocyanin; . . . ., allophycocyanin; ——, carotenoid

metrically. The 'dark-greening mutants', as represented by mutant III–*D*–2 (Fig. 2), are, however, visually green when grown in the dark. Cells of this mutant contain both chlorophyll *a* and carotenoid pigments, and like the dark-greening *S*–1 and *S*–5 *C. caldarium* mutants described by Allen[3], phycocyanin is also formed. The level of all pigments in the dark-grown, dark-greening mutant is lower than in light-grown wild-type cultures; however, light-grown cultures of the dark-greening mutants consistently accumulate more of each pigment than similarly grown wild-type cells.

(2) *Phycobilin-less mutants.* Light-grown cultures of this variant form, represented by mutant III-*C* (Fig. 2), accumulate chlorophyll *a* and carotenoid pigments but no measurable phycobilins. The absorption band seen at 615 mμ in spectra of whole-cell suspensions of this mutant appears to be that of a minor band of chlorophyll *a*. Absorption spectra of fractions obtained by calcium phosphate chromatography of aqueous extracts of ground III-*C* mutant cells appear to confirm the absence of phycobilins in this mutant.

(3) *A chlorophyll-less mutant.* The obligately heterotrophic mutant, *GGB* (Fig. 2), produces phycobilins and carotenoid pigments when grown in light, but no chlorophyll has been found. Ultra-violet irradiation of this mutant has yielded the following variant cell type.

(4) *A chlorophyll-less, phycobilin-less mutant.* Light-grown cultures of mutant *GGB*-*Y* (Fig. 2) accumulate no chlorophyll or phycobilin pigments. Carotenoids are found to be present in these cells.

Studies of the action spectrum for the formation of phycocyanin in the chlorophyll-less mutant (*GGB*) have shown that cultures exposed to 30,000 foot-candle min. of either 450 or 600 mμ light form this pigment; whereas a similar exposure to light of 550, 660 or 700 mμ results in no measurable formation of phycocyanin. The effects of light of other wave-lengths have not yet been investigated. The effectiveness of 600 mμ light in formation of phycocyanin in *C. caldarium* is in agreement with the recent work of Hattori and Fujita[6], in which it was noted that the effective part of the spectrum relative to phycocyanin and allophycocyanin formation in *Tolypothrix tenuis* lies somewhere between 550 and 700 mμ. It was, however, further noted by Hattori and Fujita[6] that blue light, ranging in wave-length from 400 to 550 mμ, was ineffective in inducing the formation of phycocyanin and allophycocyanin in *T. tenuis*. The screening effect of the chlorophyll in cells of *T. tenuis* might account for the difference in the

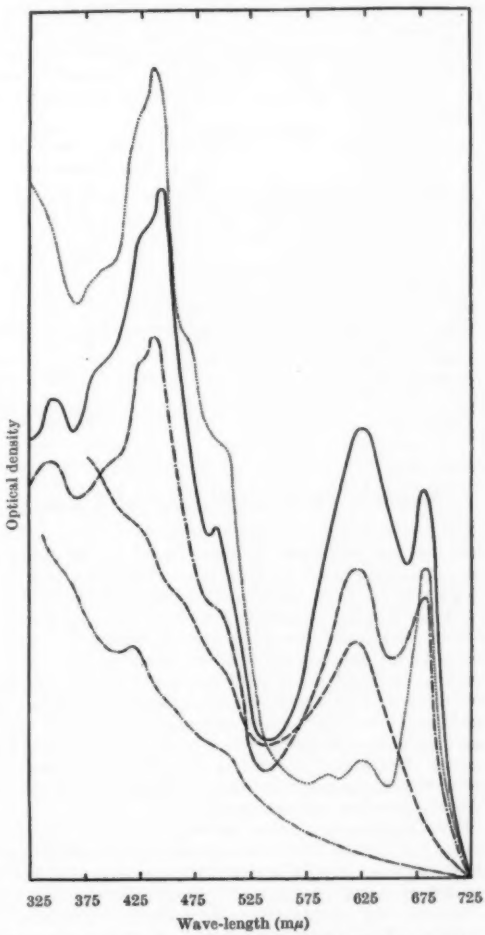

Fig. 2. Absorption spectra of cell suspensions of *Cyanidium caldarium* using the opal glass technique of Shibata (ref. 5). Cell types: —·—, wild; ——, III-*D*-2; . . . ., III-*C*; – – –, *GGB*; —·—·—, *GGB*-*Y*. Wild and III-*D*-2 spectra are at half-strength

observations that phycocyanin is formed in light of 450 mμ by the chlorophyll-less *C. caldarium* mutant *GGB*, but not by *T. tenuis*.

Hattori and Fujita[6] suggested, on the basis of the ineffectiveness of blue light for phycobilin formation, that the substance acting in the formation of phycocyanin and allophycocyanin could be neither chlorophyll nor carotenoids in *T. tenuis*. The existence of the phycobilin-producing chlorophyll-less *C. caldarium* mutant described here as well as the data on the action spectra provide evidence that phycocyanin and allophycocyanin are not derived from chlorophyll.

Further work on the action spectra for phycobilin formation in wild-type and mutant *C. caldarium* cells is in progress. The limited data from the present work are not inconsistent with the possibility that one or more hæm proteins might serve as photoreceptors (and perhaps as precursors) in the biosynthesis of phycobilins.

We wish to extend our thanks to Dr. Mary Belle Allen, who supplied the original culture of *Cyanidium caldarium* used in this work, and for the support provided in part by grants from the National Science Foundation and the United States Public Health Service, Institute of Arthritis and Metabolic Diseases (*A*–1010), and in part by the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago.

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Biochemical Classification of Yeasts

In a discussion of yeast taxonomy from a biochemical point of view, Barnett[1] made some valuable suggestions for its improvement. These emphasized: (1) the possibility that each group of yeasts may require its own particular set of biochemical tests; (2) that many of the biochemical tests now used in yeast taxonomy are of dubious value; (3) that our present understanding of the diverse biochemical processes carried out by these organisms is often very inadequate. The author accepted the view that taxonomy should embody a synthesis of results from various fields of inquiry, and that the progressive growth of knowledge necessarily renders any system of classification impermanent.

However, in a recent criticism of the methods employed by the Dutch school of yeast taxonomy[2,3], Barnett[4] now suggests that an improved and stable classification of the yeast fungi could eventually be achieved by employing exclusively biochemical criteria. The diagnostic value of these criteria in the comparative study of yeasts is regarded as being self-sufficient, since "imprecise and subjective morphological observations are avoided and there is no need to search for spores". It is not made clear whether this statement refers exclusively to the species-level, where, in the Dutch system, morphological distinctions are admittedly of less significance than physiological; but in any event it accords with the author's previous contention[1] that "the important thing about yeasts is their biochemical behaviour". This point of view, which appears to be common in contemporary biology, is not shared by us.

The proposal to classify yeasts by means of biochemical distinctions is evidently based on the belief that other biological criteria are, if not trivial, merely expressions of the physicochemical nature of the cell, in particular its constituent enzymes, proteins and nucleic acids, and are therefore redundant.

Barnett proposes tests which are designed to determine the enzyme content of any particular yeast in the hope that each test will reveal the presence or absence of a single enzyme. The diagnostic value of this type of investigation is indisputable since possible groupings could be envisaged from data which showed, let us say, that enzyme *X* occurs in only 25 per cent of the yeasts, or that of the 20 enzymes known to be regularly present in yeast *A*, 17 are common to yeast *B*, while only 8 are found in yeast *C* and 6 in yeast *D*. But here two questions can reasonably be asked: (1) Are such classifications supposed to reveal phylogenetic relationships, or are they primarily intended as artificial practical groupings? (2) Is a yeast cell to be regarded as nothing more then an assemblage of enzymes?

With respect to the first question, it is not clear what Barnett expects his new system of classification to reveal, apart from the presence or absence of specific enzymes and an improved understanding of the biochemical processes in which they participate. These *per se* constitute an admirable objective, though, with reference to classification, one to which the epithet 'stable' scarcely applies. The primary concern of any new microbial classification deserving of the name should be an attempt to demonstrate the natural relationships of the organisms involved. Otherwise it is mere cataloguing and devoid of intrinsic biological interest. In the absence of a fossil record of the yeast fungi, can one expect their natural relationships to be disclosed solely by a knowledge of the enzymes contained in their cells, even if this were extended to include studies of enzymatic organization and metabolic pathways? We think not. While biochemical processes are the basis of life, they are not synonymous with it, and to ignore life's outward manifestations, however subjective they may be, can only lead to an imperfect conception of the taxonomic whole: no one, in attempting to distinguish between a lion and a tiger, would ignore morphological criteria in favour of enzymatic. Although all schemes of microbial classification naturally embody a strong subjective element, certainly the truest and most satisfying picture will be derived from a synthesis and integration of all available knowledge. In the words of Pirie[5], "many different types of information can be, and should be, woven into the classificatory scheme, and there is no obvious advantage in attaching overriding importance to any one type".

As for the yeasts—that motley assemblage of micro-organisms defying definition—are we really asked to consider them as nothing more than bags of enzymes? For those who have devoted consider-

able time to observing through the microscope the multitudinous and variegated forms which these organisms assume and the beauty and elegance of their structures, it is almost an affront to be told that such observations are to be avoided because of their imprecision and subjectivity. It is not irrelevant to stress that hitherto one of the basic driving forces of the natural scientist has been his æsthetic appreciation of and affection for his subject-matter; the extinction of this attitude is likely to do no good to science in particular or to culture in general. It is understandable that the spirit of disinterested inquiry should lead man behind the outward forms of life in his search for its physical and chemical basis, but to ignore wilfully, in this unremitting itch for abstraction, that which can be perceived directly and appreciated æsthetically can never be biologically sound. It is quite true, as Barnett points out, that the factors influencing sporulation in yeasts are ill-understood, and that when a yeast will not sporulate under laboratory conditions this is no proof that it is incapable of doing so. But from this it does not logically follow that one need not search for spores. Sporulation in the ascosporogenous yeasts is indicative of sexuality, reproduction, recombination and maintenance of the species, and is a manifestation of life and evolution. For our part, we shall continue to search for it.

Through years of patient observation under the leadership of Kluyver, the Dutch school of yeast taxonomy created order out of chaos, and in spite of methodological shortcomings and imperfect knowledge, it was a magnificent attempt. As it stands to-day, it is primarily a practical system which most probably permits only faint and vague glimpses of the true phylogenetic relationships of the yeasts; but because it is based on a sound biological approach including morphology, sporulation, alternation of generations, and physiology, we believe that in the course of time it is destined to be revised rather than superseded. It is likely that such a revision will eventually encompass some of the alternative views of yeast classification[6–8], which, however, are themselves neither permanent nor stable, particularly since the evolutionary speculations which they contain are probably premature. But it is certain that besides dealing with the large number of new yeasts recently described, any taxonomic revision must include a more thoroughgoing genetic approach. Herein lie many fundamental problems: the possible elucidation of the species concept[9], the possible pooling of hereditary characters by means other than sexual reproduction[10], the determination of linkage groups and chromosome number, and the study of mutation and adaptation in their bearing on experimental evolution[9]. In addition to genetic data, more detailed knowledge is needed of the sexual process, of life-cycles, of comparative cytology, of morphological response to changing environmental conditions, of natural habitats and distribution[7], and certainly of the biochemical activities of these organisms. Here, in particular, the recent findings of instability in certain fermentative characters[11,12] may have significant taxonomic implications.

It may be expected that patient research in these various fields will gradually elucidate some of the natural relationships existing among the yeast fungi, although a complete picture of their evolutionary history is scarcely attainable. But even partial taxonomic enlightenment will not be in vain, if it can induce a sense of wonder and humility at the vast diversity of life manifest even in this small group of micro-organisms.

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BACTERIOLOGY

Knall-gas Reaction-linked Fixation of Labelled Carbon Dioxide in an Autotrophic *Streptomyces*

The occurrence of a *Streptomyces* capable of growing autotrophically in the presence of a Knall-gas (oxyhydrogen) mixture has previously been reported (*St. autotrophicus*, Takamiya and Tubaki[1]). The present work was planned to investigate the autotrophic assimilation of labelled carbon dioxide in this organism.

An autotrophic growth of *Streptomyces autotrophicus* was obtained by inoculating an inorganic medium of the following composition with spores or small flakes of fresh growth taken from a culture of the organism grown on an inorganic agar slant. (Composition of the inorganic nutrient medium: 1·22 gm. potassium dihydrogen phosphate, 2·46 gm. crystalline magnesium sulphate, 1·32 gm. ammonium sulphate, 2·8 mgm. crystalline ferrous sulphate, 1 ml. Arnon's micronutrient solution A_5, and 0·84 gm. sodium bicarbonate in 1,000 ml. distilled water (pH 7·0).) The culturing was carried out at 27° C. in an air/hydrogen gas mixture (1 : 1). After 3–4 weeks, the surface of the culture medium was found to be covered with a snow-white growth of the organism, amounting to 5 mgm. dry weight per 100 cm.^{2} liquid surface. For the purpose of comparison, heterotrophic culturing was also performed, using an organic medium containing peptone (1 per cent; pH 7·0) as the source of carbon and nitrogen. The culture was poured into a separation funnel to float the colonies to the surface of the liquid. The floating colonies were washed with distilled water and with 0·03 M phosphate buffer (pH 7·2), and desired amounts of the organism were collected by loopfuls into a reaction vessel.

The measurement of gas-uptake was performed with a Warburg manometer (27° C.) with hydrogen

Table 1. Carbon Dioxide Fixation coupled with Oxyhydrogen Reaction in *Streptomyces autotrophicus*

Gas atmosphere	Time of reaction (min.)	Radioactivity incorporated (c.p.m./mgm. cell dry weight)			Carbon dioxide fixed (calculated) (μmol./mgm. cell dry weight)	Hydrogen consumed (μl./mgm. cell dry weight)
		Insoluble	Soluble	Total		
80 per cent hydrogen + 20 per cent oxygen	10	89	1,168	1,257	0·048	7
80 per cent hydrogen + 20 per cent oxygen	30	272	2,058	2,330	0·089	21
80 per cent hydrogen + 20 per cent oxygen	90	980	4,919	5,899	0·225	56
Air	90	8	138	146		

and nitrogen introduced in the reaction vessel after evacuation of the air. A preliminary investigation revealed a marked consumption of oxyhydrogen gas in the autotrophically grown cells, which was in accord with the equation of a Knall-gas reaction. In a typical experiment, 110 μl. hydrogen and 66 μl. oxygen, as determined by the manometric method of Schatz and Bovell[3], were consumed in 50 min. by 5-mgm. dry weight cells taken from a 90 day-old autotrophic culture (endogenous respiration: 8 μl. oxygen-uptake). No Knall-gas reaction was detected with heterotrophically grown cells of the same organism.

An isotope experiment was performed to detect the capacity of the organism to fix inorganic carbon. Autotrophically grown cells (80 day-old) were floated on the surface of a 0·03 *M* phosphate buffer (*p*H 7·2) placed in the main chamber of a Warburg vessel. The gas atmosphere was a hydrogen/oxygen mixture (4 : 1) freed from contamination of carbon dioxide. In the course of manometric measurement of oxyhydrogen reaction at 27° C., the solution of labelled carbon ($NaH^{14}CO_3$, 4·5 μmols; $1·18 \times 10^8$ c.p.m.) contained in the side-arm of the vessel was introduced into the main chamber. The reaction was stopped by adding 0·5 ml. of an acetic/hydrochloric acid mixture (4 : 1) after 10, 30 and 90 min. of reaction. Each sample of test organism was extracted and repeatedly washed with ethanol (final concentration, 80 per cent). The soluble fraction was separated from the insoluble cell material by centrifugation; the extract and the insoluble residue were dried in air on metal disks under an infra-red lamp. The results of the radioactivity measurements are presented in Table 1. It will be seen that bicarbonate carbon is readily incorporated by the organism when an oxyhydrogen mixture is present in the gas atmosphere. It must also be noted that the greater portion of the assimilated radiocarbon is discovered in the alcohol-soluble fraction. (Essentially the same results were obtained on stopping the reaction with boiling ethanol (final concentration, 80 per cent), instead of the acid mixture.) The efficiency of carbon assimilation as expressed by the ratio of incorporated carbon to consumed hydrogen and oxygen was as follows:

$$H_2 : O_2 : CO_2 = 10 : 5 : 1$$

In another set of experiments, autotrophically grown cells (120 day-old) were pre-incubated for 70 min. at 27° C. in an oxyhydrogen gas atmosphere (or air in control experiments) freed from carbon dioxide. The gas was then removed by evacuation and flushing with air or pure nitrogen: this procedure was repeated twice. After varied periods of such *blank* incubation, the organism was supplied with $NaH^{14}CO_3$ injected through a rubber stop-cock (fitted in this case instead of the side-arm of Warburg vessel), and further incubated for 10 min. to be tested for the amount of fixed carbon dioxide. All the experimental procedures after the introduction of acid mixture were the same as those described above. From the results presented in Table 2, it will be seen that the capacity for carbon dioxide fixation under the conditions of these experiments remains unabolished for some time. Under aerobic conditions in the blank period, however, a significant decrease in fixation capacity occurs, so that after 3 min. in air, the fixation capacity of the test organism was as low as about 30 per cent that of the anaerobic control.

Table 2. Carbon Dioxide Fixation in *Streptomyces autotrophicus* pre-incubated with Oxyhydrogen Gas Mixture

Pre-incubation (for 70 min.)	Condition of blank incubation after removal of hydrogen gas (min.)	Reaction with $^{14}CO_2$ (min.)	Total radioactivity incorporated (c.p.m./mgm. cell dry weight)
80 per cent hydrogen + 20 per cent oxygen	in air 0·5	10	513
	in air 3·0	10	319
	in air 10·0	10	219
	in N_2 3·0	10	935
	in $H_2 + O_2$ (that is, no gas exchange)	10	1,290
Air	in air (that is, no gas exchange)	10	143

It can be concluded from these results: (1) That the autotrophically grown cells of *Streptomyces autotrophicus* are capable of fixing carbon dioxide. (2) The utilization by this organism of the energy derived from the oxyhydrogen reaction is also evident, the endogenous fixation of carbon dioxide in the absence of hydrogen gas being negligibly small. It is also to be noticed (3) that the inducing effect of the oxyhydrogen reaction on carbon dioxide assimilation is retained, for some time, in cells pre-treated with the gas mixture. The occurrence of a Knall-gas reaction-linked fixation of carbon dioxide has repeatedly been observed in the group of hydrogen bacteria[3–6]. However, this type of autotrophic carbon assimilation has not yet been reported in the class of actinomycetes. The sluggishness of the process in our test organism, which may also be the

Table 3. Knall-gas Reaction-linked Fixation of Carbon Dioxide in Hydrogenotrophic Autotrophs

Organism	Q_{H_2} (μl./hr., mgm., cell dry weight)	Q_{CO_2} (μl./hr., mgm. cell dry weight)	Efficiency $CO_2 : H_2$
*Hydrogenomonas facilis**	446	72	1 : 6·2
Hydrogenomonas ruhlandii†	264	34	1 : 7·8
Streptomyces autotrophicus‡	37	3·4	1 : 10·9

* Manometric data by Schatz (ref. 3).
† Manometric data by Packer and Vishniac (ref. 4).
‡ Isotopic experiments (present work, see Table 1).

cause of the slowness in its growth, is conspicuous, although the efficiency of the assimilatory process, as expressed by the carbon dioxide/hydrogen ratio, is not inferior. For the purpose of comparison, typical data in this connexion are summarized in Table 3 together with our own results. The slow rate found in the present case may partly originate from the circumstance that we had to use cells taken from old cultures, often several weeks old, in order to secure sufficient amounts of the organism for the test.

We wish to acknowledge here the continuous interest of Prof. H. Tamiya, University of Tokyo, during this work, which was supported in part by a research grant from the Ministry of Education.

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Action of 6-Aminopenicillanic Acid on Gram-negative Bacteria

THERE is abundant evidence to support the theory that at least one way in which penicillin exerts its antibacterial effect is to prevent the synthesis, during cell division, of a rigid component of the cell wall. If this action takes place in normal culture medium, the result is lysis; if in a hypertonic environment, the cell changes into a spherical body or spheroplast[1]. We have found that the parent amine, 6-aminopenicillanic acid[2], from which the natural penicillins may be considered to be derived by acylation, induces morphological changes similar to those produced by benzylpenicillin, 6-(α-phenoxypropionamido)penicillanic acid ('Broxil'), and phenoxymethylpenicillin (penicillin V).

In our experiments, 0·15 ml. of a 17-hr. culture of the organism, grown on a rotator at 37° C., was added to 10 ml. of the following medium, containing per litre: sodium chloride 5 gm., 'Lab. Lemco' (Oxoid) 5 gm., peptone 10 gm., sucrose 114 gm., crystalline magnesium sulphate 2·5 gm. The sodium salt of 6-aminopenicillanic acid was added to give the desired final concentration. Examination by interference microscopy after incubation for 4–5 hr. at 37° C. gave the results shown in Table 1.

Table 1. CONCENTRATIONS OF SODIUM BENZYLPENICILLIN AND SODIUM 6-AMINOPENICILLANATE TO INDUCE SPHEROPLAST FORMATION IN CERTAIN GRAM-NEGATIVE BACTERIA

	Sodium benzyl-penicillin (μmole/ml.)	Sodium 6-amino-penicillanate (μmole/ml.)
E. coli (formerly N.C.T.C. 5934)	0·167	0·68–1·7
Cloaca cloacae (N.C.T.C. 8155)	0·167	0·34
E. coli (*K*12)	1·67	3·4
Ps. pyocyanea (N.C.T.C. 7244)	0·42	0·84
Serratia marcescens	1·67	1·7–3·4
Proteus vulgaris (N.C.T.C. 7052)	1·67	1·7–3·4

It can be seen that sodium 6-aminopenicillanate in concentrations approximately twice those of sodium benzylpenicillin induced spheroplast formation. In lower concentrations, bizarre morphological variants were obtained. The spheroplasts underwent lysis on dilution of the medium with water.

Batchelor *et al.*[3] report that 6-aminopenicillanic acid possesses definite antibacterial properties, but of a much lower order than benzylpenicillin. It would appear that the presence of the acyl side-chain on the primary amine is not essential for spheroplast formation. Quantitative differences may be due to factors involving access to the site of action.

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VIROLOGY

Serological Detection of a Virus in Cherry Trees with a Leaf Roll Disease

LEAF roll virus disease of sweet cherry (*Prunus avium*)[1,2] has been identified (by graft-transmission to indicator plants) in eight orchards in Kent and one in Worcestershire. Six of these outbreaks have been investigated further, and in each of them the same virus was isolated from infected trees. When buds or young leaves were macerated in 0·05 *M* phosphate buffer (*p*H 7·8) or 0·01 *M* sodium diethyl-dithiocarbamate solutions and rubbed on to the leaves of young herbaceous plants, chlorotic and necrotic spots, rings and lines developed on the leaves of tobacco (var. White Burley), while *Chenopodium amaranticolor* plants were stunted, with mottled and distorted leaves. The virus was also transmitted by sap inoculation from tobacco to *Prunus avium* and *P. pennsylvanica* seedlings, and from *Prunus avium* to *P. pennsylvanica*.

An antiserum was prepared by intravenous injections into a rabbit of virus preparations precipitated from the infective tobacco sap by ammonium sulphate.

Precipitation tests were made in a gel containing 0·7 per cent 'Ionagar' No. 2, 0·9 per cent sodium chloride and 0·02 per cent sodium azide. This medium was run into Petri dishes to a thickness of 3 mm., and holes cut in the gel with a small cork borer to receive diluted antiserum or antigen. Single precipitation lines formed between holes filled with antiserum and those with undiluted sap from *Chenopodium* plants infected with this virus. No precipitation lines formed with sap from healthy *Chenopodium* plants or from plants infected with *Arabis* mosaic and tomato black ring viruses.

Specific precipitation lines were formed when sap from buds or young leaves from infected cherry trees was used as the antigen; the sap was antigenic

when diluted 1 : 2 with water, phosphate buffer or sodium diethyl-dithiocarbamate and also when undiluted. No precipitation lines formed with similar preparations from trees infected with *Arabis* mosaic, raspberry ringspot, necrotic ringspot, little cherry, ring mottle and rusty mottle viruses.

There is no previous record of the transmission of a virus within or between species of *Prunus* by sap inoculation, and none has proved antigenic in cherry sap except necrotic ring spot and sour cherry yellows, which need to be purified and concentrated before they can be detected serologically[3].

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A Lipid Component of Murray Valley Encephalitis Virus

Following the early work of Taylor *et al.*[1], it is generally believed that the arthropod-borne viruses contain ribonucleic acid, protein and lipid. Recent work has shown that the ribonucleic acid fraction extracted by phenol from several viruses of this group is infective[2]. In the intact virus the protein fraction probably protects this ribonucleic acid and may have other functions. The present report considers a lipid component of the virus of Murray Valley encephalitis virus, and shows that this virus is inactivated by phospholipase *A*.

Crude virus was prepared as a 20 per cent baby mouse brain extract and purified virus was prepared from such a suspension[3]. Standard infective ribonucleic acid was prepared by treating crude virus with phenol[4]. Virus and ribonucleic acid were titrated on the chorioallantoic membrane of chick embryos[4]. Phospholipase *A*, supplied to us by Miss H. Doery of the Commonwealth Serum Laboratories, had been purified from the venom of the black snake (*Pseudechis porphyriacus*) (Doery, H. M., and Pearson, S. E., to be published). To ensure that so far as possible the only functional enzyme in the preparation was phospholipase *A*, each sample was boiled for 10 min. in physiological saline (*p*H 6·0) before being used.

Equal volumes of undiluted virus and phospholipase diluted in physiological saline were mixed and held at 37° C. for 30 min. The remaining infective virus was titrated. Both crude and purified viruses were rapidly inactivated by 100 μgm./ml. of phospholipase *A* (Table 1). The inactivated virus preparations were then treated with phenol to liberate infective ribonucleic acid. The yield of ribonucleic acid was always higher than the titre of virus, a result which indicated that phospholipase *A* acted on some component of the virus other than the ribonucleic acid.

Table 1. Infective Titre of Virus, and Potential Yield of Ribonucleic Acid after Treatment of Murray Valley Encephalitis Virus with Phospholipase *A* (37° C., 30 min.)

	Control	Treated
Crude virus		
Titre of virus	7·0*	0·4
Yield of ribonucleic acid	4·5	2·5
Pure virus		
Titre of virus	8·0	0·6
Yield of ribonucleic acid	5·0	1·6

* Log_{10} titres of infectivity.

Titration of the enzyme was attempted by using serial dilutions of enzyme in the above system, and defining the end-point as that concentration of enzyme which reduced the infectivity of undiluted virus by 2 logs. The end-point against crude virus was consistently at 0·05 μgm./ml. of enzyme. The end-point against purified virus varied from 2·0 to 0·1 μgm./ml. in 10 experiments: this wide variation was thought to be related to the varying lability of purified virus at 37° C., even in the absence of phospholipase *A*.

Standard infective ribonucleic acid prepared from crude virus was much less susceptible to phospholipase *A* than was virus, the end-point of the enzymic action against ribonucleic acid being at 100 μgm./ml. The high concentration suggested that the action was due to a contaminant and not to the phospholipase *A*. For example, the presence in the phospholipase preparation of 7 parts per million of a nuclease similar to pancreatic ribonuclease could explain the result[4].

From the above results, it was concluded that Murray Valley encephalitis virus was inactivated by the cleavage of fatty acid(s) from phospholipid(s) contained in its structure. It was unlikely that infective ribonucleic acid contained lipid as a vital component.

Purified influenza virus is known to contain large amounts of phospholipid. Influenza virus strain *WSE* was purified from infected allantoic fluid[5], and treated with phospholipase *A* (1,000 μgm./ml., 37° C., 30 min.) both with and without added normal baby mouse brain extract. Virus infectivity, as titrated in the allantoic cavity of chick embryos, was not reduced by this treatment. The failure of phospholipase *A* to inactivate influenza virus might mean either that intact phospholipid was not necessary for infectivity, or that the phospholipid was not accessible to the action of the enzyme.

Two interpretations of the results with Murray Valley encephalitis virus seem to be possible. The most direct hypothesis is that viral phospholipid has a specific function during infection of the chorioallantoic membrane. For example, it might assist in the absorption of virus to host cell, or might allow the virus particle to react with some intracellular system. A second possibility is that the phospholipid is not functional in this sense. It might be largely host cell lipid incorporated during intracellular growth or emergence of virus from the host cell; or it might be synthesized under the influence of the viral genome. In any event it will contribute to viral structure. On this view the alteration of phospholipid in a mature Murray Valley encephalitis virus particle might so distort the viral architecture as to render the particle non-infective.

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[1] Taylor, A. R., Sharp, D. G., Beard, D., and Beard, J. W., *J. Infect. Dis.*, **72**, 31 (1943).
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[5] Ada, G. L., and Perry, B. T., *J. Gen. Microbiol.*, **14**, 623 (1956).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, December 5

INSTITUTE OF METAL FINISHING (at the Café Royal, Regent Street, London, W.1), at 2.30 p.m.—Annual General Meeting, followed by Prof. J. W. Cuthbertson: "A Metallurgist's Thoughts on Electrodeposition" (Hothersall Memorial Lecture).

BRITISH SOCIETY FOR THE PHILOSOPHY OF SCIENCE (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. G. Buchdahl: "Model, Symbol and Fact".

UNIVERSITY COLLEGE (in the Physiology Theatre, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. W. Feldberg, F.R.S.: "Mediators of Allergic Reactions".*

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. John O. Corliss (University of Illinois): "Phylogeny and Evolution of the Ciliated Protozoa—Application to Systematics".* (Last of three lectures on "The Evolution of the Protozoa".)

Tuesday, December 6

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. D. O. Heinrich: "Study on Electro-Precipitator Performance in Relation to Particle Size Distribution, Level of Collection Efficiency, and Power Input".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND CONTROL SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Prof. D. Gabor, F.R.S., Dr. W. P. L. Wilby and Dr. R. Woodcock: "A Universal Non-Linear Filter, Predictor and Simulator, which Optimizes Itself by a Learning Process".

RESEARCH DEFENCE SOCIETY (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. J. H. Burn, F.R.S.: "Testing Drugs on Man" (Twenty-ninth Stephen Paget Memorial Lecture).

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, London, S.W.7), at 5.30 p.m.—Prof. H. Elliot: "Cosmic Rays and the Exploration of Space" (Inaugural Lecture).

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel, Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. D. G. Catcheside: "Functional Structure of Genes".* (Fourteenth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

ROYAL AERONAUTICAL SOCIETY, ASTRONAUTICS AND GUIDED FLIGHT SECTION (at 4 Hamilton Place, London, W.1), at 6 p.m.—Dr. G. H. S. Young: "Solid Propellant Rocket Motors".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. G. Phillips and Mr. P. Walker: "Newer Methods of Testing Paint Film".

BRITAIN CHINA FRIENDSHIP ASSOCIATION, HAMPSTEAD BRANCH (at Hampstead Town Hall, Haverstock Hill, London, N.W.3), at 7.45 p.m.—Dr. Joseph Needham, F.R.S.: "China and the Development of World Science".

Wednesday, December 7

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2 p.m.—Dr. A. E. Kellie: "Steroid Assays".*

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Mr. A. J. Miller; "A Queueing Model for Road Traffic Flow"; Mr. J. C. Tanner: "Delays on a Two-Lane Road".

INSTITUTE OF FUEL (at the Instituton of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Mr. P. A. Alexander, Mr. R. S. Fielder, Mr. P. J. Jackson, Mr. E. Raask and Mr. T. B. Williams: "Acid Deposition in Oil-fired Boilers, Comparative Trials of Additives and Testing Techniques".*

INSTITUTE OF PETROLEUM (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Mr. M. E. Hubbard: "The Changing Energy Pattern in Europe and Its Possible Effect on Product-Mix".

SIR THOMAS MIDDLETON MEMORIAL TRUST (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. J. D. Findlay: "Cattle and Climate" (Eighth Memorial Lecture).

BRITISH INSTITUTION OF RADIO ENGINEERS, RADAR GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. H. G. Hinckley: "Flight Evaluation of Airborne Electronic Equipment".

SOCIETY FOR ANALYTICAL CHEMISTRY (in the Main Chemistry Lecture Theatre, Imperial College, Imperial Institute Road, London, S.W.7), at 6.30 p.m.—Discussion Meeting on "The Flask Combustion Technique".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in Room 411, Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Prof. Fritz Heider: "On Person Perception".

Wednesday, December 7—Friday, December 9

SCIENTIFIC AND TECHNICAL GROUP of the ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (in the Lecture Theatre of the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2)—Conference on "The Ultimate Sensitivity in Photography—To-day and To-morrow".

Thursday, December 8

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Bryan Matthews, F.R.S., and Mr. T. C. D. Whiteside: "Tendon Reflexes in Free Fall"; Mr. Q. Bone: "The Organization of the Atrial Nervous System of *Amphioxis* (*Branchiostoma*)".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. Ravenscroft: "The Determination of the Electrical Characteristics of an Arc Furnace".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. E. J. L. Lowbury: "Drug Resistance and the Response to Chemotherapy". (Last of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W. C.1), at 5.30 p.m.—Sir Solly Zuckerman, F.R.S.: "The Social Function of Science—1960" (Rickman Godlee Lecture).*

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 7 p.m.—Prof. M. Stacey, F.R.S.: "Aromatic Fluorine Compounds".

CHEMICAL SOCIETY (in the Lecture Theatre, The Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Prof. R. Huisgen: "1,3-Dipolar Cycloadditions" (Centenary Lecture).

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Symposium on "Hookworm Diseases". Contributors: Dr. S. Stott, Dr. E. van Oye and Dr. Henry Foy.

Friday, December 9

ASSOCIATION OF APPLIED BIOLOGISTS (at the Royal Entomological Society, 41 Queen's Gate, London, S.W.7), at 10.15 a.m.—Paper Reading Meeting.

BRITISH PSYCHOLOGICAL SOCIETY, OCCUPATIONAL PSYCHOLOGY SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. John Spencer: "Thoughts about Automation".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. R. L. F. Boyd: "Rocket Astronomy".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

POSTGRADUATE STUDENT (recent graduate with a good degree in physics or physical chemistry) IN THE DEPARTMENT OF PHYSICS, to research under the supervision of Dr. J. G. Powles on some aspects of magnetic resonance—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (December 9).

RESEARCH ASSISTANT (graduate biochemist or biologist with training in chemistry) IN THE ZOOLOGY DEPARTMENT, to assist in research in tank culture or bivalve shellfish—The Registrar, The University, Southampton (December 10).

TUTORIAL STUDENT IN THE DEPARTMENT OF BIOCHEMISTRY—The Registrar, King's College (University of London), Strand, London, W.C.2 (December 12).

SCIENTIFIC OFFICER, Grade 1 (with an honours degree in physics, mathematics or electrical engineering, and preferably some postgraduate experience in ionospheric research) AT THE WEAPONS RESEARCH ESTABLISHMENT, Salisbury, near Adelaide, Australia, to engage in research and development work in the field of ionospheric physics—The Senior Representative (AV,91/6), Department of Supply, Australia House, Strand, London, W.C.2 (December 15).

SCIENTIFIC OFFICER, Grade 1 (with an honours degree in physics, and preferably some research experience) AT THE WEAPONS RESEARCH ESTABLISHMENT, Salisbury, near Adelaide, Australia, for research and development in physics, mainly in the field of solid state and infra-red physics—The Senior Representative (AV.89/6), Department of Supply, Australia House, Strand, London, W.C.2 (December 15).

FELLOW or SENIOR FELLOW IN PHILOSOPHY within the Department of Social Philosophy, Institute of Advanced Studies, Australian National University—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, December 30).

SENIOR LECTURER/LECTURER IN SCIENTIFIC THOUGHT in the School of Philosophy, University of New South Wales, Kensington, N.S.W., Australia—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (Australia and London, December 30).

POST-DOCTORAL RESEARCH FELLOW IN PHYSICAL CHEMISTRY, to study properties of solids by mass spectrometry—The Registrar, The University, Edgbaston, Birmingham 15 (December 31).

READER-IN-CHARGE (with a special knowledge of the physical and dynamic aspects of the subject) OF METEOROLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, December 31).

CHAIR OF THEORETICAL PHYSICS at Birkbeck College—The Academic Registrar, University of London, Senate House, London, W.C.1 (January 5).

LECTURERS (2) IN CHEMISTRY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia and London, January 6).

CHAIR OF CIVIL ENGINEERING—The Registrar, University College, Singleton Park, Swansea (January 14).

JAMES WATT CHAIR OF ELECTRICAL ENGINEERING—The Secretary of University Court, The University, Glasgow (January 14).

POSTGRADUATE RESEARCH FELLOW IN THE DEPARTMENT OF BOTANY, for the study of micro-organisms involved in cellulose decomposition—Prof. C. J. Hickman, Department of Botany, University of Western Ontario, London, Ontario, Canada (February 28).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN CHEMISTRY, PHYSICS, METALLURGY, ENGINEERING, GEOLOGY, AGRICULTURAL SCIENCE and related subjects—The Registrar of the University of Wales, University Registry, Cathays Park, Cardiff (March 6).

ASSOCIATE PROFESSOR OF CLINICAL PSYCHOLOGY—Prof. F. Hilton Page, Head of the Department of Psychology, Dalhousie University, Halifax, Nova Scotia, Canada.

DEMONSTRATOR/LECTURER (with a degree in physics or general science) IN THE DEPARTMENT OF PHYSICS, Middle East Technical University, Ankara—Room 139, Foreign Office, London, S.W.1.

PHYSICIST, CHEMICAL or MECHANICAL ENGINEER, Scientific/Senior Scientific Officer grade (with a first- or second-class honours degree in physics, chemical or mechanical engineering), at the Fire Research Station (D.S.I.R.), Elstree, Herts, to join a group studying the growth and spread of fire—Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.484/0A.

POSTDOCTORATE FELLOW (suitably qualified candidate interested in theoretical calculations of the hydrogen bond energy between water molecules and the energy of ice as a function of hydrogen orientation)—Dr. E. S. Campbell, Department of Chemistry, New York University, New York 53, N.Y., U.S.A.

SENIOR LECTURER (with an honours degree and suitable teaching and research experience, and preferably a higher degree and specialization in modern and atomic physics) IN PHYSICS—The Clerk to the Governors, South-West Essex Technical College and School of Art, Forest Road, Walthamstow, London, E.17.

SENIOR LECTURER (with qualifications and experience to teach mathematics for the Diploma of Technology courses and for degree courses in engineering and science) IN MATHEMATICS—The Registrar, Bradford Institute of Technology, Bradford 7.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Current Bibliography for Aquatic Sciences and Fisheries, Vol. 3, Part 1. Compiled by F. A. O. Fisheries Biology Branch. Pp. iv+184. 17*s.* 6*d.*; 2.60 dollars. Subscription price per volume of 12 parts £9 0*s.* 0*d.*; 27 dollars. (London: Taylor and Francis, Ltd., 1960. Published by permission of the Food and Agriculture Organization of the United Nations.) [188

Aslib. Survey of Information/Library Units in Industrial and Commercial Organizations. Survey carried out by Dr. D. J. Campbell. Results analysed and Report prepared by C. W. Hanson. Pp. vi+42+vi. (London: Aslib, 1960.) 12*s.* 6*d.* (Aslib members 10*s.*) [198

Report of the Astronomer Royal for Scotland for the year ending 31st March 1960. Pp. 8. (Edinburgh: The Royal Observatory, 1960.) [198

Geological Society of London. Memoir No. 2: Geological Results of Petroleum Exploration in Britain 1945–1957. By Norman Leslie Falcon and Percy Edward Kent. Pp. 56+5 plates. (London: Geological Society of London, and H. K. Lewis and Co., Ltd., 1960.) 25*s.* net. [198

Electrical Distribution, Vol. 1, No. 1 (July, 1960). Pp. 24. (The News Magazine of the Cable and Construction (Cables and Lines) Divisions of Associated Electrical Industries, Ltd.). (London: Associated Electrical Industries, Ltd., 1960.) [198

Northampton College of Advanced Technology. Part-Time Day and Evening Courses, Session 1960–61. (London: Northampton College of Advanced Technology, 1960.) [198

Bulletin of the British Museum (Natural History). Entomology. Vol. 9, No. 6: Notes on East African Ephemeroptera, with descriptions of New Species. By D. E. Kimmins. Pp. 337–355. 7*s.* Vol. 9, No. 7: Notes on the Shrew-Flea *Doratopsylla dasycnema* (Rothschild), and Notes on *Palaeopsylla*, a Genus of Siphonaptera. By F. G. A. M. Smit. Pp. 357–388. 10*s.* Vol. 9, No. 8: Some New Diaspidini (Coccoidea: Homopyera) from Africa. By D. J. Williams. Pp. 387–399. 6*s.* (London: British Museum (Natural History), 1960.) [198

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Season 1958–59. Tanganyika Territory—Eastern Province. By R. Smith, E. W. Valentine, and J. E. Cross. Pp. 15. 2*s.* 6*d.* Kenya. By M. S. Hastie. Pp. 9. 2*s.* 6*d.* Survey of Reports. By H. E. King. Pp. 10. 2*s.* 6*d.* (London: Empire Cotton Growing Corporation, 1960.) [228

Northern Advisory Council for Further Education. Thirteenth Annual Report, 1959/1960. Pp. 48. (Newcastle-upon-Tyne: Northern Advisory Council for Further Education, 1960.) [228

Nuclear Engineering Abstracts, Vol. 1, No. 1 (July, 1960). Pp. 100. Subscription rates: Annual subscription covering four issues, post paid, £6 6*s.* 0*d.* (18.50 dollars). Single copies, if available, post paid £1 12*s.* 6*d.* (4.75 dollars). (London: Silver End Documentary Publications, Ltd., 1960.) [238

Building Research Station Digest. Second Series. No. 1: Research and Its Users. Pp. 4. (London: H.M. Stationery Office, 1960.) 4*d.* [129

Planning, Vol. 26, No. 444 (12 September, 1960): Local Self-Government—The Experience of the United Kingdom, the Isle of Man, and the Channel Islands. Pp. 229–280. (London: Political and Economic Planning, 1960.) 5*s.* [129

Royal Society of Medicine. Annual Report of the Council, 1959–1960. Pp. 23. Calendar of the Royal Society of Medicine, 1960–1961. Pp. 42+ix. (London: Royal Society of Medicine, 1960.) [129

Family Planning Association. 29th Annual Report 1959–60. Pp. 20. (London: Family Planning Association, 1960.) [129

Air Ministry: Meteorological Office. Scientific Paper No. 2: Conservation of Vorticity at 100 Millibars. By J. R. Probert-Jones. Pp. ii+13. (M.O. 673.) (London: H.M. Stationery Office, 1960.) 2*s.* 6*d.* net. [129

Other Countries

United States Department of the Interior: Geological Survey. Water-Supply Paper 1541–B: Double-Mass Curves. By James K. Searvy and Clayton H. Hardison. With a section "Fitting Curves to Cyclic Data" by Walter B. Langbein. Pp. iv+31–66. 20 cents. Water-Supply Paper 1569: Surface Water Supply of Hawaii, 1956–58. Prepared under the direction of J. V. B. Wells. Pp. vii+295. Professional Paper 334–B: Fossils of the Littleton Formation (Lower Devonian) of New Hampshire. By A. J. Boucot and Robert Arndt. Pp. iii+41–51+3 plates. 25 cents. Professional Paper 334–G: Dispersion Characteristics of Montmorillonite, Kaolinite, and Illite Clays in Waters of Varying Quality, and their Control with Phosphate Dispersants. By B. N. Rolfe, R. F. Miller and I. S. McQueen. Pp. iv+229–273. 40 cents. Professional Paper 312: Geology and Quicksilver Deposits of the Terlingua District, Texas. By Robert G. Yates and George A. Thompson. Pp. v+114+22 plates. (Washington, D.C.: Government Printing Office, 1959 and 1960.) [198

Report and Accounts of the National Botanic Gardens of South Africa, Kirstenbosch, Newlands, Cape; The Karoo Garden, Worcester; and the Harold Porter Botanic Reserve, Betty's Bay, for the financial year ended 31 March 1960. Pp. 32. (Kirstenbosch, Newlands: National Botanic Gardens, 1960.) [228

The Rubber Research Institute of Malaya. (A Brochure describing the research and advisory work of the Institute with an introductory note on the early history of rubber research in Malaya.) Pp. ii+17. (Kuala Lumpur: Rubber Research Institute of Malaya, 1960.) [228

Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. Comptes Rendus de Recherches. No. 24 (Aout 1960): Travaux du Comité pout l'Étude du Fluage des Métaux aux Températures Ordinaires. Pp. 169. (Bruxelles: Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture, 1960.) 200 Belgian francs. [228

Population Reference Bureau, Inc. *Population Bulletin*, Vol. 16, No. 5 (August, 1960): U.S.A. Population in 2050 One Billion? Pp. 89–106. (Washington, D.C.: Population Reference Bureau, Inc., 1960.) 50 cents. [228

United States Department of Agriculture. Farmers' Bulletin No. 2148: Aphids of Leafy Vegetables: How to Control Them. By W. J. Reid, Jr., and F. P. Cuthbert, Jr. Pp. 16. (Washington, D.C.: Government Printing Office, 1960.) 10 cents. [228

Singapore. Memoirs of the Raffles Museum, No. 4, (May 1957): The Journal of Thomas Otho Travers, 1813–1820. Edited by John Bastin. Pp. 226+10 plates. (Singapore: Government Printer, 1960.) 12*s.* 6*d.*; 5 Malayan dollars. [228

Mitteilungen aus der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Berlin-Dahlem. Heft 99 (Juni 1960): Hackfruchtkrankheiten und Nematodenforschung. Pp. 119. (Berlin und Hamburg: Verlag Paul Parey, 1960.) [228

Annals of the South African Museum. Vol. 45, Part 5: Notes on the Biology of the Lutjanidae, (Pisces) of the East African Coast, with special reference to *L. Bohar*. By F. H. Talbot. Pp. 549–573. 3*s.* 3*d.* Vol. 45, Part 6: A New Sollfugid Arachnid from Table Mountain, Cape, *Solpuga grindleyi*, SP.N. By A. C. Brown, Pp. 575-579. 1*s.* (Cape Town: South African Museum, 1960.) [228

Mitteilungen der Sternwarte der Ungarischen Akademie der Wissenschaften. Nr. 45: Bericht Über Optische Beobachtungen Anläßlich der Landung der Sowjetischen Mondrakete Lunik II. Von L. Detre. Pp. 10. (Budapest: Sternwarte der Ungarischen Akademie der Wissenschaften, 1960.) [238

Indian Forest Bulletin No. 223 (New Series, Entomology): Insect Pests of Flowers, Seeds and Fruits of Forest Trees. By R. N. Mathur, Balwant Singh and Kishori Lal. Pp. 105. (Delhi: Manager of Publications, 1958.) Rs. 7.50; 11*s.* 6*d.* [238

University of California Publications in Geological Sciences. Vol. 37, No. 2: The Geolabidinae: a New Subfamily of Early Cenozoic Erinaceoid Insectivores. By Malcolm C. McKenna. Pp. 131–164. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 75 cents. [238

Mycopathologia et Mycologia Applicata. Vol. 13, Supplementum: Iconographia Mycologica. By O. Verona and T. Benedek. Plates A 47–84, C 26–33, D 7–10. (Den Haag: Uitgeverij Dr. W. Junk, 1960.) [268

World Health Organization. Technical Report Series, No. 199: Post-Basic Nursing Education Programmes for Foreign Students—Report of a Conference, Geneva, 5–14 October, 1959. Pp. 47. 2 Swiss francs; 3*s.* 6*d.*; 0.60 dollars. Monograph Series, No. 45: Differential Diagnosis of Yaws. By C. J. Hackett and L. J. A. Loewenthal. Pp. 88 (52 figures). 10 Swiss francs; 17*s.* 6*d.*; 3.25 dollars. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) [149

Southern Rhodesia. Report of the Trustees and Director of the National Museums of Southern Rhodesia for the year ended 31st December, 1959. Pp. 21. (Bulawayo: National Museum of Southern Rhodesia, 1960.) [149

Review of Studies in the Flow of Information Among Scientists. Vol. 1: Text. Pp. v+62. Vol. 2: Tables. Pp. ii+48. (Prepared for the National Science Foundation.) (Washington, D.C.: Bureau of Applied Social Research, Columbia University, 1960. Available from the National Science Foundation, Office of Science Information Service, Washington, D.C.). [149

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